PB81-154098

Conservation and Alternative Fuels in the Transportation Sector

Solar Energy Research Inst.
Golden, CO

25 Jun 80

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO. PB81-154098
4. TITLE AND SUBTITLE Conservation and Alternative Fuels in the Transportation Sector		5. REPORT DATE June 25, 1980
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Solar Energy Research Institute Transportation Task Force 2565 Plymouth Rd. Ann Arbor, MI 48105		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Solar Energy Research Institute 1617 Cole Blvd. Golden, Colorado 80401		13. TYPE OF REPORT AND PERIOD COVERED Technical
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report is a product of the Transportation Task Force of the Solar Energy Research Institute (SERI) Solar/Conservation Study. The overall goal of the study has been to develop a coordinated set of policies designed to minimize U.S. consumption of non-renewable energy resources. This report represents the Transportation Task Force input to the overall SERI study report.

This report presents a set of new transportation energy conservation policy initiatives. From an energy efficiency viewpoint the efforts to improve the efficiency of automobiles, airplanes and trucks can be most effective. Likewise, shifting passengers from automobiles and airplanes to buses and trains, and shifting freight from aircraft and trucks to trains (and where practical, marine or pipeline modes) will provide the largest energy savings.

The time we are able to buy through conservation should not be wasted. The U.S. should pursue the development of synthetic crude, as is being done. Alternative fuels and vehicles that can efficiently use these fuels should be developed in parallel. In particular, major emphasis should be placed on the production and efficient use of methanol, even in preference to supporting synthetic crude programs.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Transportation Energy Conservation Automotive fuels Methyl alcohol Mass transportation Motor vehicles Automobiles	Methanol Synthetic crude	

18. DISTRIBUTION STATEMENT Release unlimited	19. SECURITY CLASS *(This Report)* unclassified	21. NO. OF PAGES 439
	20. SECURITY CLASS *(This page)* unclassified	22. PRICE

EPA Form 2220-1 (9-73)

PB81-154098

CONSERVATION
and
ALTERNATIVE FUELS
in the
TRANSPORTATION SECTOR

Prepared by

The Transportation Task Force
of the SERI Solar/Conservation Study

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

CONSERVATION
and
ALTERNATIVE FUELS
in the
TRANSPORTATION SECTOR

Prepared by

The Transportation Task Force
of the SERI Solar/Conservation Study

Date: First Draft: March 11, 1980
Second Draft: May 5, 1980
Final: June 25, 1980

DATE: January 14, 1981

SUBJECT: Transmittal of the Transportation Task Force Report of the Solar Energy Research Institute Solar/Conservation Study

FROM: Charles L. Gray, Jr., Chairman
Transportation Task Force
Charles Gray, Jr.

TO: Denis Hayes, Chairman
Steering Committee

Attached is the report generated by the Transportation Task Force for the Solar Energy Research Institute Solar/Conservation Study. It is my belief that these materials, together with such other information as you may receive and SERI's in-house analysis, provide a solid basis for your final report.

The transportation sector is the critical component of our national energy problem. Our energy crisis is a liquid fuel crisis. Motor vehicles are the dominant users of liquid fuels and are unique in their dependence on liquid fuels. The transportation sector consumes over half of our petroleum. Yet, motor vehicle mobility is at the very foundation of modern American society, and strong transportation conservation measures which are both simple and effective have not been found and/or implemented.

The purpose of the transportation study was to generate ideas which might reduce energy consumption, and to then analyze those proposals which could be shown to offer the potential for significant petroleum conservation in the transportation sector, regardless of past evaluations or current popularity. It was recognized that many of the proposals would involve negative impacts and would be very controversial. Unlike many such reports, which attempt to make absolute policy judgments and to produce a single comprehensive package of initiatives as a final recommendation, this report examines each proposal independently from the others. Rather than producing a single group of final recommendations (which rarely make it through the political process unscathed anyway), this report analyzes a wide range of candidate initiatives which will hopefully stimulate an open discussion over their merits. The public policy decisions of which candidate initiatives should be implemented and how they should be coordinated should follow, not precede, this discussion.

We believe our efforts have been successful. This report offers a wide range of candidate initiatives which could save significant amounts of petroleum in the transportation sector, and analyzes the accompanying economic, safety, and environmental impacts. Because highway vehicles consume three-fourths of all transportation energy, many of the proposals involve improving the energy efficiency of automobiles and trucks through improved technology; the most far-reaching of these initiatives describes the energy savings associated with corporate average fuel economy (CAFE) targets for automobiles and light trucks of 50 miles per gallon in 1990 and 80 miles per gallon in 1995. Our analysis indicates that these CAFE targets are technically feasible if American car buyers should decide that fuel efficiency is more important than excess performance and size. A second means of transportation energy conservation is to shift passengers and freight from energy inefficient modes (single-occupant auto, airplane, truck freight) to energy efficient modes (carpool, vanpool, bus, railroad freight); one initiative in this section presents an aggressive federal plan to rebuild the railroads and to develop an improved heavy truck user fee system by enacting a nationwide weight-mileage fee based on gross vehicle weight, maximum axle loading, and mileage. Finally, initiatives were developed analyzing the potential and desirability of non-petroleum transportation fuels such as methanol, ethanol, and synthetic hydrocarbon fuels from coal, shale, and biomass (with methanol being preferred because of supply, environmental, and energy efficiency advantages) and analyzing the concept of a tax on imported petroleum.

The impacts of implementing some (or all) of the initiatives contained in this report may be such that it would be better for the nation to not implement them at all, i.e., the savings in energy and any other benefits simply might not outweigh their negative effects. In a world with decreasing liquid petroleum supplies and escalating prices, and with the U.S. relying on foreign sources for about half of its crude oil, I believe all the proposals in this Task Force report deserve serious consideration as SERI prepares its final recommendations.

Attachment

EXECUTIVE SUMMARY

The United States is now importing about half the petroleum it consumes, with the proportion of petroleum imports projected to continue increasing. In the absence of greatly increased energy conservation, projected world demand for petroleum will approach productive capacity by the early 1980's and substantially exceed capacity by 1985. The dependence on foreign petroleum is a grave threat to the United States.

The transportation sector consumes more than half of the total petroleum consumed in the United States. This is due in large part to the fact that many U.S. metropolitan and most rural communities are completely dependent on automobile and truck transport. Some driving is admittedly discretionary but freedom of personal transportation is of great importance to many Americans; major challenges to this freedom would be vigorously opposed.

Clearly though, transportation energy conservation must be the key component of any effort to reduce petroleum consumption. For example, reducing transportation energy consumption by 16 percent would save as much petroleum as would switching power plants to coal. In the longer term alternative fuels must replace petroleum as the energy source for transportation, and a sound, aggressive policy must be developed and initiated now to have any assurance that this fuel transition will take place without a devastating effect on the U.S.

What is needed is a set of specific policy initiatives to which this country will commit. Action, oriented toward implementation of a set of sound initiatives, is critical to the establishment of a sense of confidence in national energy policy, and is necessary to sustain a successful implementation effort. Decisions have to be made. Probably the toughest decisions will not be technical - they will be political. We may not agree with all the political decisions, but that's beside the point. The necessary decisions must be made soon so that everybody knows which way we are going.

Transportation energy conservation should be viewed as a source of energy. If we can save even a gallon of gasoline for every three we burn, that's a gallon available for another or future use. The key questions are: How much energy is available from conservation?, and How much does that gallon of gasoline that we obtained from conservation cost?

This report presents a set of new transportation energy conservation policy initiatives. From an energy efficiency viewpoint the efforts to improve the efficiency of automobiles, airplanes, and trucks can be most effective. Likewise, shifting passengers from automobiles and airplanes to buses and trains, and shifting freight from aircraft and trucks to trains (and where practical, marine or pipeline modes) will provide the largest energy savings. Table 1 presents the conservation potential for the technology (energy efficiency improvement) and mode shifting initiatives, as well as the "cost" of the energy saved.

When considering the need to conserve energy though, we must consider the "cost" of the energy we consume as more than just the price we pay. That cost must reflect the depletion of a precious finite resource (for non-renewable energy). When viewed in years to come and by future generations, the cost of the energy we consumed will be a cost far greater than what we pay today. The cost of energy today must also reflect the national security implications (economically and militarily) of the fact that the United States is now importing over half the oil it is using.

The estimates presented in Table 1 should only be considered as general indications of energy savings and conservation costs. This is because the energy savings are not constant with time (while most go up, some go down with time) and the "cost" of the energy saved is a function often of several assumptions. For example, the value assumed for the extra time necessary per person for a trip was $25 per hour for the New Short-Haul Aircraft initiative, $5 per hour for the Enforce 55 mph initiative, and $20 per hour for the 45 mph for Heavy Trucks initiative. (For more detail, the individual initiatives should be consulted). Also, the total potential savings through the implementation of all these initiatives are not necessarily directly additive. Figure 1 presents a graphical overview of the effect of implementing all of these initiatives on projected transportation energy utilization. (While projections of transportation energy demand vary, Figure 1 is also useful to indicate proportional energy savings based on different demand forecasts).

Only one initiative proposes to obtain energy savings directly through discouraging its use. This is the initiative to tax imported petroleum - an economic disincentive. The analysis investigates taxes on gasoline versus imported petroleum, and the relationship of such taxes to the ongoing automotive fuel economy standards program. Absent any further conservation efforts, the proposed tax on imported petroleum of: $10/barrel as soon as possible, $20/barrel by 1985, and 100 percent of the cost of the petroleum by 1990, is projected to reduce total petroleum consumption (from both transportation and non-transportation sectors) by almost 250,000 barrels per day in the near term, 500,000 barrels per day after 1985, and over a million barrels per day after 1990. However, with increasingly stringent new car fuel economy levels, much of the savings will be "shared". One way to view the tax's effect is to consider it as modest pressure on the consumer to buy more fuel efficient cars. In any case, that portion of the savings which is obtained from the passenger car mode should not be double-counted when considering the implementation of both initiatives. Figure 1 provides an estimate of the extra transportation energy savings from the petroleum tax.

Table 1

Technology and Mode-Shifting Initiatives

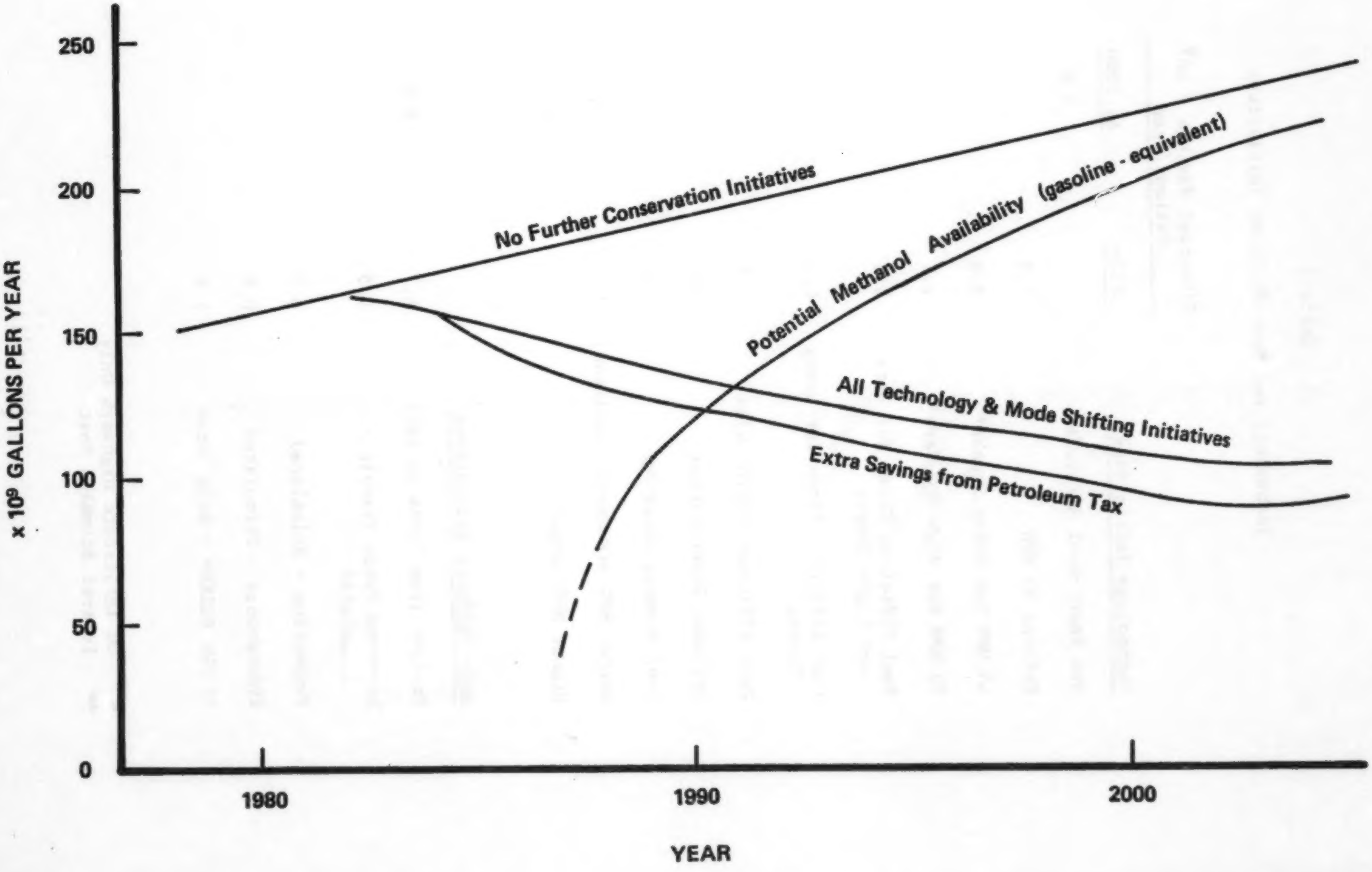
	Potential Savings x 10^9 Gallons/Year		"Cost" $/Gallon
Technology Initiatives	1980-	by 2000	
New Short-Haul Aircraft		5.8	0.25
Enforce 55 MPH	1.5		6.70
45 MPH for Heavy Trucks*	2.8		2.10
70 MPH for High MPG Cars*	2.1		—
Fuel Efficient Tires for Cars and Light Trucks	6.1		0.18
Fuel Efficient Tires for Heavy Trucks	1.5		0.75
Fuel Efficient Engine Oils	4.9		0.13
Cylinder Deactivation	3.1		0.24
Fuel Economy Check-Up	0.9		0.09
Better MPG Standards Compliance	1.4	3.1	—
Higher MPG Targets		76.7	—
Mode Shifting Initiatives			
Freight from Truck to Rail	4.7	8.2	—
Improved Urban Transit - Stimulated	0.5		1.30**
Vanpooling - Stimulated	0.6		0.35**
Videophones - Stimulated	0.8		0.20**
70 MPH BUSES* - Stimulated	2.8		0.16**

---

* On Interstate Highways Only

** Federal Stimulus Cost

FIGURE 1 TRANSPORTATION ENERGY PROJECTIONS



The time we are able to buy through conservation should not be wasted. Longer term solutions should be aggressively pursued now. The United States should pursue the development of synthetic crude, as is being done. However, we should not "put all of our eggs in one basket." Alternative fuels and vehicles that can efficiently use these fuels should be developed in parallel. In particular, major emphasis should be placed on the production and efficient use of methanol, even in preference to supporting synthetic crude programs. Especially in the critical near-term, the production of methanol from coal and biomass appears much greater than that of syncrude from coal or oil shale. For the longer term, methanol still looks more attractive than syncrude, due in part to the fact that methanol can be produced from renewable sources. In fact, despite the results of older studies, more recent analyses have shown methanol to be preferred over synthetic gasoline based on economics, energetics and environmental risks.

There is a certain inertia which propels the development of syncrudes and hinders the development of new fuels because syncrudes would fit in nicely with existing refineries, distribution systems and motor vehicles and the new fuels would require some changes. These factors must be duly considered, but they are not overriding and should not be considered as such. Thus, a well-balanced attack on the problem of providing secure supplies of liquid fuel for this country appears to be the best approach at this time.

By the year 2000, methanol from coal and biomass appears to have the potential to provide a significant part of the nation's liquid fuel requirements - about 5 million barrels per day gasoline-equivalent from renewables and about 4 to 8 million barrels per day gasoline-equivalent from coal. Figure 1 shows the effect of the full methanol production capability being made available for transportation use. However, the limiting factor for methanol use is not production capability, but rather consumptive capacity. The existing transportation vehicle fleet could not utilize methanol without extensive modification. Since vehicles must be initially produced with the ability to use methanol, the phase-in of a methanol-tolerant fleet becomes the limiting factor for methanol use. Therefore, beginning in 1987, all new highway vehicles should be required to have the capability to use methanol.

Conservation must be the foundation of a solid energy policy, with renewable resources receiving at least an equivalent priority to the increased production of non-renewable energy sources.

FOREWORD

This report is a product of the Transportation Task Force of the Solar Energy Research Institute (SERI) Solar/Conservation Study. In late 1979 SERI was asked by Deputy Secretary of Energy John Sawhill to develop a detailed program for reaching national goals in solar energy and energy conservation. The overall goal of the SERI Solar/Conservation Study has been to develop a coordinated set of policies designed to minimize U.S. consumption of non-renewable energy resources. This report represents the Transportation Task Force input to the overall SERI study report. The information and recommendations contained in this report will be reviewed by SERI and combined with data from other sources in the overall SERI report which will be issued separately. This task force report should not necessarily be construed to represent the views of the Solar Energy Research Institute or the Department of Energy.

A prestigious review panel was assembled to provide a detailed critique of the report. The review panel represents an outstanding cross-section of expertise in the transportation sector. The members participating on the review panel were asked to provide critiques of this report from individual perspectives, which would not necessarily represent the views or position of the organizations which employ them. The review panel has had the opportunity to review two drafts of the report, and a meeting was held between releases of the two drafts.

The Appendix is a compilation of most of the written comments received. The review panel member from Volkswagen submitted detailed comments on the "More Stringent and/or Restructured Fuel Economy Levels for Automobiles and Light Trucks" initiative, which were requested to be treated "confidentially," and other comments were "for internal use only." In addition, many comments were received verbally. The reader of this report is encouraged to review the comments contained in the Appendix.

The policy recommendations contained herein were made by the task force and do not necessarily reflect the position of individual panel members or the organizations with which they are employed.

Transportation Task Force

Charles Gray, Jr., Chairman

Karl Hellman
Jeff Alson
Dwight Atkinson
Glenn Thompson
Dill Murrell
Rick Rykowski
Tom Cackette
Pete Hutchins
Tim Cox
Rebecca Waring
John White
Gary Jones
Ed LeBaron
Phil Lorang
Tom Penninga
Doug Noddings
Kevin Geraghty
Gary Fields

Transportation Review Panel

1. Thomas Austin, Executive Officer
   California Air Resources Board
2. Frank Davis, Professor of Transportation
   Marketing & Transportation Dept. - University of Tennessee
3. Clarence Ditlow, Executive Director
   Center for Auto Safety
4. Samuel Dodson, Coordinator, Strategic Planning
   Corporate Planning - Exxon
5. Angus Duncan, Director for Energy Policy
   Department of Transportation
6. James C. Echols, Executive Director
   Tide-Water Transportation District
7. Thomas J. Galbreath, Executive Engineer
   Emission Control Analysis & Planning - Ford Motor Company
8. Frank von Hippel, Senior Research Scientist
   Center for Energy & Environmental Studies, Princeton University
9. Karl Heinz Neumann, Manager - Engine Development/Emissions
   Volkswagenwerk AG (U.S. Contact L. Lawrence Nutson)
10. Gerald F. Stofflet, Manager
    Automobile Emission Control - General Motors Corporation
11. Richard B. Stoner, Vice-Chairman
    Cummins Engine Company
12. Edwin L. Thomas, Vice-President, Engineering
    Air Transport Association
13. William J. Woehrle, Manager, Industry Standards
    Uniroyal Tire Co.

NOTE: Members of the review panel provided technical input to one or more of the initiatives presented. However, the initiatives and their recommendations are the work of the task force itself, and should not be construed to (and in some cases do not) represent the views of the review panel, its individual members, or the organization which they represent.

Conservation and Alternative Fuels in the Transportation Sector

TABLE OF CONTENTS

Page

I. INTRODUCTION

Preface I-1

Supply/Demand Analysis I-2

Policy History I-4

New Policy Initiatives I-6

II. IMPROVING TRANSPORTATION ENERGY EFFICIENCY THROUGH THE USE OF TECHNOLOGY

Aircraft

- Assure that New Short-Haul Commerical Aircraft Have Improved Fuel Efficiency II-3

Highway Vehicles

- Enforcement of 55 MPH National Speed Limit II-22
- Fuel Savings from Better Enforcement and/or Lowering of Heavy-Duty Vehicle Speed Limit II-30
- Increased Speed Limits for More Fuel Efficient Cars on Interstate Highways II-56
- Low-Energy Dissipation Tires for Automobiles and Light Trucks . . . II-63
- Low-Energy Dissipation Tires for Heavy-Duty Trucks II-81
- Fuel Efficient Engine Oils II-108
- Improved Engine Efficiency Through Cylinder Deactivation II-122
- A Fuel Economy Check-Up to Assure Proper Fuel Economy Maintenance II-133
- An Energy Conservation Example Should Be Set by the Federal Fleet . . . II-143

TABLE OF CONTENTS (cont'd)

Page

Highway Vehicles (cont'd)

- More Stringent Enforcement of the Corporate Average Fuel Economy Standards II-152
- More Stringent and/or Restructured Fuel Economy Levels for Automobiles and Light Trucks II-158

III. TRANSPORTATION MODE SHIFTING

- Shift of Freight Transport From Trucks to Rail Through the Elimination of the Government Subsidy Differential III-7
- An Initiative to Encourage Urban Transit System Modernization and Expansion III-30
- Encouraging Vanpooling III-44
- Energy Savings Through the Increased Use of Video Telephone Conferences III-59
- Time and Cost Incentives for Modal Shifts to Intercity Bus III-67

IV. ECONOMIC DISINCENTIVES - A TAX ON IMPORTED PETROLEUM IV-1

V. ALTERNATIVE FUELS V-1

VI. POLICY RECOMMENDATIONS VI-1

VII. RECOMMENDATIONS FOR ADDITIONAL POLICY ANALYSIS AND RESEARCH NEEDS

- Reduce Peak Period Congestion at Major Air Carrier Airports VII-2
- Increased Utilization of Rail Piggyback Service for Intercity Freight Movement VII-6
- Railroad Nationalization. VII-10

APPENDIX

I. INTRODUCTION

Preface

Transportation not only consumes more than half of the total petroleum consumed in the United States, it also offers the largest near-term conservation opportunities. U.S. demands for transportation energy per capita exceed those in most other developed nations by a factor of 2 to 4. This is due in large part to the fact that many U.S. metropolitan and most rural communities are completely dependent on automobile and truck transport. Some driving is admittedly discretionary but freedom of personal transportation is of great importance to many Americans; major challenges to this freedom would be vigorously opposed.

Finite resources inevitably mean changes in life-styles. But this can be a transition of real improvement in life-styles - provided that we plan wisely now for the future. Lofty philosophizing about energy policy will not bring about this end; what is needed is a set of specific policy initiatives to which this country will commit. Action, oriented toward implementation of sound initiatives, is critical to the establishment of a sense of confidence in national energy policy, and is necessary to sustain a successful implementation effort. Decisions have to be made. Probably the toughest decisions will not be technical - they will be political. We may not agree with all the political decisions, but that's beside the point. The necessary decisions must be made soon so that everybody knows which way we are going. Conservation must be the foundation of a solid energy policy, with renewable resources receiving at least an equivalent priority to the increased production of nonrenewable energy sources.

When considering the need to conserve, we must consider the cost of the energy we consume as more than just the price we pay. That cost must reflect the depletion of a finite resource (for non-renewable energy), which in years to come and for future generations will be a cost far greater than what we pay today. The cost of energy must also reflect the national security implications (economically and militarily) of the fact that the United States is now importing over half the oil it is using.

Federal energy conservation policy should seek to maximize cost effective energy conserving investments and in-use behavior changes, while minimizing the need for energy curtailment and abrupt life-style shifts. To the extent possible, energy policy decisions should be those that will enhance employment opportunity and not penalize the poor.

The structure of this document moves the reader rapidly to and focuses upon new conservation policy initiatives which, if implemented, will significantly reduce the projected transportation energy demand.

Supply/Demand Analysis

This section presents a concise overview of the expected direct energy demands of the various transportation modes to provide a framework for the identification of potentials for conservation. The data relied upon for this study comes largely from: Transportation Energy Conservation Book, Edition III, Oakridge National Laboratory, February 1979. There has been no attempt made to challenge the information and projections presented in this reference; however, more specific energy use calculations were necessary in some instances.

The transportation sector accounted for 25.4 percent (19,300 x 10^{12} Btu) of the total U.S. energy consumption in 1977. Transportation consumed between 52 and 56 percent of the petroleum used in the U.S. in 1977 (about 9.9 x 10^6 bbl/day of oil). (17 percent went for residential and commercial uses - mostly for space conditioning, 19 percent went to industrial uses - 9 percent of that for chemical feed stock, and 9 percent was consumed by utilities.) In the last couple years the U.S. has been importing over half of its petroleum. In the absence of greatly increased energy conservation, projected world demand for oil will approach productive capacity by the early 1980's and substantially exceed capacity by 1985.1/

Clearly, transportation energy conservation must be a major component of any overall energy conservation policy - and the key component of any effort to reduce petroleum consumption. For example, reducing transportation energy consumption by 16 percent would save as much petroleum as would switching power plants to coal. In the longer term alternative fuels must replace petroleum as the energy source for transportation, and a sound, aggressive policy must be developed and initiated now to have any assurance that this fuel transition will take place without a devastating effect on the U.S.

Table 1 shows the proportion of transportation energy consumed by each of the major transportation modes in 1977 and projections for the year 2000 (assuming no additional conservation initiatives are implemented). By the year 2000 transportation energy consumption will be 28,300 x 10^{12} Btu (or about 14.7 x 10^6 bbl/day of oil). Table 1 clearly illustrates the importance of reducing the fuel consumed by automobiles, trucks, and airplanes.

Table 2 shows the average energy intensity of the major transportation modes (using 1976 load factors). Automobiles consumed an average of 4,310 Btu per passenger-mile in urban travel in 1976, while urban mass transit consumed less than half that amount. Yet public transportation use has steadily declined. Automobiles account for over 95 percent of all urban passenger traffic. 95 percent of urban driving could be satisfied with a 45-mile range vehicle. Commuting uses about 1/3 of all automobile gasoline (about 2 million bbl/day). 27 percent of the commuters

Table 1

Transportation Energy Use

	1977	2000
Automobile	52.1%	39%
(Light Truck)	(10.8%)	(11.5%)
All Truck	25.5%	27%
Air	8.3%	16%
Marine	5.6%	5%
Rail	3.1%	4%
Pipeline	2.9%	5%
Bus	0.7%	0.7%
Other	1.2%	3.3%

Table 2

Transportation Energy Intensity

	Passenger Transport (Btu/Passenger-mile)	Freight Transport (Btu/Ton-Mile)
Automobile & Light Truck	4300 (3500 for small cars)	—
Rail	3000 to 3500	400 to 700
Bus	1000 to 3000	—
Air	6200 to 8300	22000 to 28000 (3500 for "Belly" Freight)
Truck (Heavy Commercial)		2500 to 4500
Marine		500
Pipeline		500

commute 10 or more miles one way, but they travel 69 percent of the commuter miles. 6 percent of the commuters use public transit, 65 percent drive alone, and 19 percent use car/van pools.2/

Automobiles carry about 85 percent of all intercity passenger traffic while railroads and buses - the most energy-efficient modes - carry only 3 percent of the traffic. Airplanes consume even more energy per passenger-mile than automobiles and are the fastest growing mode of intercity passenger transport (from 4 percent in 1960 to 10 percent in 1970) yet in 1970 airplanes consumed 22 percent of the energy used to transport intercity passengers in this category.

In freight transportation, the trend has been the same. Rail transport is four times as efficient (measured as Btu's per ton-mile) as truck transport and 32 times as efficient as air transport, yet railroads are losing freight traffic to trucks and planes. In 1977, heavy trucks accounted for 24 percent of the total intercity freight ton-miles, while rail, pipeline, water and air accounted for 37.5 percent, 24.2 percent, 16.1 percent, and 0.2 percent of the total freight ton-miles, respectively.

From an energy efficiency viewpoint the efforts to improve the efficiency of automobiles, airplanes, and trucks can be most effective. Likewise, shifting passengers from automobiles and airplanes to buses and trains, and shifting freight from aircraft and trucks to trains (and where practical, marine or pipeline modes) will provide the largest energy savings.

Policy History

Energy use in transportation has been influenced by a long history of government policies. Some of these policies concerned transportation explicitly, while others affected transportation only indirectly. In any case, the form and function of our transportation system always has been determined by government as well as by private sector decisions. The issue then is not whether a government policy on transportation energy is needed, but rather, how existing government policies affecting transportation (both explicit and implicit) should be reformed or supplemented to meet the needs of an age of energy scarcity.

From the earliest days of human civilization, governments have taken an active role in transportation. Ancient empires constructed and regulated roads, postal systems, aqueducts, ports, canals and shipping. In America, transportation has always been a mixture of private and public facilities and services. With the rise of the industrial age, the government role in transportation became increasingly significant. The development of railroads was somewhat dependent on government support in the form of generous land grants and delegation of eminent domain powers; later, the railroads were the first major industry to come under government regulation. The characteristics of our automobiles, trucks and aircraft, the relative use of the various transportation modes, and the transportation inefficient way our urban areas developed, have all been influenced by government policies over the past century and longer.

Though the government policies that have influenced the development of our transportation system are complex and numerous, a few examples stand out. Clearly, the transportation energy problem is related to the decline of energy-efficient rail transport and the rise of less efficient car/truck/air transport. The decline of the railroads is in part a consequence of ICC regulatory policies and government subsidies for other transportation modes.

The evolution of cars and trucks as the major transportation modes would not have been possible without government provision of a vast network of paved highways. The federal ABC program of 1946 provided Federal subsidies for the construction of primary and secondary highways. The National Defense Highway Act of 1956, which established the Highway Trust Fund and the interstate highway system, committed the U.S. to an alternative to rail transport which was specifically dependent on the availability of inexpensive petroleum-based fuels.

The effects of the 1956 Highway Act on energy use were compounded by a tacit policy, following the Second World War, to promote urban sprawl into low-density suburbs. The FHA and VA home mortgage programs virtually demanded suburbanization. Transportation policies facilitated the trend, by simultaneously subverting urban mass transit system and rail passenger service, and promoting the use of the automobile.

And the rise of air transportation, which is the least energy-efficient transportation mode (and the one most dependent on the unique properties of petroleum-derived fuels), also depended on government support. Development of commercial aviation technology has been accelerated greatly by Federal defense and space programs. Commercial aviation was based in its early days mostly on government post office contracts. The creation of the FAA was essential to the establishment of commercial aviation, and the creation of the CAB facilitated the growth of the major commercial air carriers. And in 1970, the Airport and Airways Development Act, based on the model of the Federal highway program, created a trust fund to subsidize the development of commercial airports.

The result of all this is a national transportation system which lies at the heart of our energy crisis. The amount of petroleum consumed just by motor vehicles on our highways is approximately equal to the amount of petroleum we now import from other countries, and accounts for over half the total amount of petroleum used annually. In some of the more sparsely populated states (in the Midwest and Rocky Mountains), motor vehicles account for 80 percent or more of the petroleum consumed.

So our near-term crisis is primarily a transportation crisis. And the difficulty our nation has experienced in attempting to deal with its energy problems over the past decade derive in large measure from the scale, inertia, and the overwhelming dependence on a limited variety of petroleum-derived fuels necessary for the nation's transportation system - a system encouraged and promulgated by government policies over many decades.

But through all of this it is only fair to note that previous government policies have been most directly shaped by an apparent abundance of inexpensive energy (and in particular, inexpensive petroleum) and by a developing society's desire for rapid and flexible transportation. The real question now is, what are the government policies that can most effectively deal with providing necessary transportation services in an era of dwindling energy supplies?

New Policy Initiatives

Several policy tools are available to encourage energy conservation, including providing information to the consumer, economic incentives/disincentives, research and development of new technologies and the use of regulatory powers. But first, decisions must be made regarding what conservation initiatives should be implemented, then the "correct" mix of policy forces can be chosen - with specific consideration to what is most appropriate for each initiative.

In deciding whether a conservation initiative should be implemented, a background of why and how energy is consumed in the target-area of the initiative is necessary to provide a perspective of how fuel can be saved. The fuel conservation potential of the candidate initiative should be clearly derived; there must be certainty in the fuel conservation potential of the candidate initiative before it can be given serious consideration. The cost to implement the candidate initiative must be considered, as well as the feasibility of implementation considering the supply of any new technology necessary in the time frame of interest. The impacts of implementation must also be thoroughly evaluated. In particular, economic, environmental, safety, and foreign dependency impacts must be assessed. Finally, in evaluating the following initiatives the energy efficiency of the required infrastructure should also be considered. In particular, any initiative that would require the construction of major new highways or major new rail systems would add substantial indirect energy consumption to offset the projected benefits of the initiative. Initiatives that make use of the existing transportation facilities will therefore have a conservation advantage, relative to indirect energy use. The indirect energy consumed in manufacturing transportation vehicles should also be considered. Table 3 gives the result of such an analysis.3/ The indirect energy consumption is highest for

Table 3

Indirect Energy Consumed in the Manufacture of Transportation Vehicles

Type of Vehicle	Auto, Standard Size	Bus, Intercity	Conventional Rail, Intercity	Air Transport, Medium Haul
Seating	6	44	94	180
Total energy1/ to manufacture new vehicle, BTU x 10^9	0.133	1.02	65	20
Miles in vehicle lifetime, 10^6	0.1	1.0	3.0	30
Indirect manufacture energy per seat-mile, BTU/seat-mile	222	23	250	4

automobiles and railroad cars. This indirect energy consumption would add another 14 percent to the direct operating energy for the automobile, for example. (For a more complete analysis of indirect energy consumption see, "Urban Transportation and Energy: the Potential Savings of Different Modes," Prepared by the Congressional Budget Office, September, 1977.)

The initiative should be implemented then, if significant energy conservation can be derived from implementation of the initiative, if implementation is feasible and cost effective, and if implementation is politically and socially acceptable, considering its impacts. Once a decision is made that a candidate conservation initiative should be implemented, then the tools of implementation should be evaluated to define the most appropriate and cost effective approach.

The public must know what the more energy efficient choice is, and the life cycle cost of one choice versus another, before they can be expected to make energy conserving choices in the marketplace. The market forces do not always make this an easy or simple implementation option. For example, the makers of bias ply tires would strongly oppose the making of rolling resistance information available to potential customers or purchasers of their product. When the purchase decision can be cost justified to the consumer, this implementation option can be effective - provided the information is effectively made available to him.

Federal research and development programs to supplement private sector efforts can sometimes accelerate the development of innovative equipment and processes for which there may not be a strong near-term need identified in the private sector. Federal research and development will also allow policy decision makers to be kept better informed relative to conservation potentials, where other implementation initiatives such as economic incentives/disincentives or regulations may be necessary.

Economic incentives/disincentives can also change consumption practices. Economic incentives to purchase more fuel efficient technology or use more fuel efficient transportation modes can take the form of tax credits, accelerated depreciation schedules, guaranteed low interest loans, and in some cases direct subsidies such as rebates. Tax structures which inherently recognize the energy efficiency of a product or service will provide economic incentives/disincentives. Many still contend that low energy prices of the past are the source of today's energy supply difficulties. Not only have low prices caused Americans to consume too much energy, but it has also reduced efforts to provide for more supply. However, even increasing energy prices above the replacement cost may not reduce energy consumption rapidly enough, considering the energy consumption inertia already in place. Also, considering the lag time necessary to bring forth greater supplies of energy, inflated energy prices today cannot yield rapid results in terms of increased supply. Artificially raising energy prices will not reduce the time needed to turn over, in an orderly basis, the energy-using capital stock now in existence and to, without some major sacrifices, change basic life-style patterns in this country.

Rapidly increasing energy prices may result in large profits for energy companies and would be a hardship on some who may have limited alternatives. (The basic issue of economic disincentive versus regulations is treated elsewhere in this document.) In any case, economic disincentives (e.g., taxes) can have the same conservation effect as standards and regulations, but each implementation option has its own drawbacks.

Establishing standards and regulations to ensure energy efficient consumer choices can reduce energy consumption more rapidly and orderly than would occur through natural market forces. Regulations would normally be used where the market forces would not be expected to bring about the needed change as rapidly as desired. Regulations if not carefully structured would eliminate consumer choices that may be needed and justified in spite of the goal of the regulation. Regulatory development and enforcement cost as well as compliance cost must always be considered. However, the cost of compliance will also result with other implementation options that are effective, and some government implementation costs will also be inherent.

The task force considered and evaluated to various degrees a wide variety of transportation energy conservation ideas. Those ideas which appeared to satisfy the requisite acceptance criteria were then developed into candidate initiatives for inclusion in this report. These candidate initiatives are presented in four sections.

The first section deals with initiatives that can improve transportation energy efficiency through the use of available technology. There are several new technology-based fuel conservation initiatives which can be implemented without curtailment of service, transportation mode shifting, or reducing the total vehicle-miles-traveled in transportation, and are implementable now. The attractiveness of these technology-based initiatives is that in general they can be initiated in the near-term, without sacrifices and reduced services, and provide substantial fuel savings in a cost-effective manner. Most of the petroleum consumed over the next 5 to 10 years will be consumed by vehicles now in service, and for those vehicles, substantial conservation potential exists. This country must conserve petroleum now to buy time to develop long-range solutions, such as more fuel efficient future vehicle fleets, well-planned mode shifting where appropriate, and alternative fuels. Over the mid to long-term the fuel consuming characteristics of transportation vehicles must change. For new vehicles, much greater flexibility exists in the application of new technology than is available to existing fleets, and several initiatives are presented that affect new transportation vehicles. All of the initiatives will not only save petroleum, but will also provide significant financial savings to the public.

The next section includes conservation initiatives which suggest changes to the existing transportation usage characteristics. The shifting of use patterns among the modes to achieve an optimum fuel utilization efficiency offers substantial conservation potential. As was discussed earlier, the shifting of passengers from automobiles and airplanes to buses and trains, and the shifting of freight transport from aircraft and trucks to trains (and where practical, marine or pipeline modes) will provide the largest energy savings. The difficult problem with mode shifting is, of course, how to accomplish such changes without serious and significant economic impacts on important components of the U.S. industry and without major sacrifices being called for on the part of individuals.

The third section deals with alternative fuels. Two separate groups of alternative fuels are considered. One group of fuels are those that can be obtained from renewable energy sources. Since the transportation sector is almost totally dependent on petroleum and because of the need to transport the source of energy with the vehicle, increasing the renewable energy used by transportation probably presents a larger challenge than increasing the renewable energy used by other energy consuming sectors. The other group of fuels are those that can be derived from non-petroleum, non-renewable energy sources.

The final section includes a single initiative. This initiative focuses on energy conservation through increasing directly the price of energy.

References

1/ "The International Energy Situation: Outlook to 1985," Central Intelligence Agency, April 1977.

2/ Conservation Objectives Paper, Department of Energy, January 1980.

3/ Mascy, A.C. and Williams, L.F., "Air Transportation Energy Consumption: Yesterday, Today, and Tomorrow," American Institute of Aeronautics and Aeronautics Paper 75-319, February, 1975.

II. IMPROVING TRANSPORTATION ENERGY EFFICIENCY THROUGH THE USE OF TECHNOLOGY.

Aircraft

The airline industry is a very sophisticated, cost-conscious industry. While fuel efficiency was considered when the commercial aircraft that are operating today were designed in the 1960's, it has now become a major design criterion for aircraft. Until 1973 the price that the airlines paid for Jet fuel had remained essentially constant for many years. However, since then fuel prices have risen substantially. Overall, fuel now (1980) accounts for about 30 percent of the air carrier industry's operating cost, up from 12 percent in 1973 (fuel prices have risen from 11 cents/ gallon in 1973, to 52 cents in mid 1979, to 80 cents/ gallon at the end of 1979). These recent changes in the importance of fuel costs in the economics of aircraft operation have stimulated the industry to begin conservation measures.

Several alternative methods for increasing the energy efficiency of air transportation are available. These include improved operational procedures, modifications to current in-service aircraft, improvements in future production units of current production aircraft types, and new technology aircraft. Aircraft operating efficiency can be improved by increasing the number of seats on the aircraft, increasing the percentage of seats occupied (load factor), flight procedure modifications, and increased aircraft maintenance. The modification of current in-service aircraft types offers additional potential for improvement of aircraft energy efficiency. These modifications range from improved aerodynamic components to new engines. New production aircraft offer the potential for the incorporation of more energy efficient features such as stretching the fuselage, adding aerodynamic improvement features, reducing aircraft weight and improving the efficiency of the engines. The design of all new aircraft with fuel conservation as a primary goal offers the largest long range potential.

In order to accelerate the development of advanced technology for future aircraft energy efficiency improvements, the National Aeronautics and Space Administration initiated in 1975 an aircraft energy efficiency program. The NASA program is a comprehensive, 10-year research program which involves research in propulsion systems, aerodynamics, and structures. While much can be expected to come from this program, the program seems to be focusing on design speeds in the Mach 0.8 to 0.85 range. This inherently eliminates the large energy saving option associated with flying turbo-prop or prop-fan powered aircraft at their optimum energy efficiency of Mach 0.7 (or lower).

The airlines have already accomplished a lot in the direction of improved fuel conservation. As a result, the energy efficiency of the U.S. scheduled airlines has risen from 17.5 passenger-miles per gallon in 1973 to about 25 in 1979. Due to the growing significance of fuel cost and the technical sophistication of the industry in regards to energy conservation measures, it is expected that significant additional progress in increasing the energy efficiency of air travel will be made. The new aircraft conservation initiative discussed in this section is one which may not otherwise be implemented if left to the market forces alone.

This new initiative improves the energy efficiency of aircraft operation through the use of improved technology. This initiative is designed to assure that new short-haul (less than 1000 mile trips) commercial aircraft have the improved fuel efficiency associated with the new prop-fan engine design optimized to a speed of Mach 0.7. Another aircraft initiative is recommended for further policy analysis (Section VII) based on the reduction of peak period congestion at major air carrier airports, which reduces the energy consuming holding patterns required of approaching aircraft and the idling of aircraft lined up for take-off.

Assure That New Short-Haul Commercial Aircraft Have Improved Fuel Efficiency

Summary

If all aircraft serving the less than 1,000-mile trip market were of a new prop-fan technology optimized for a cruise speed of Mach 0.7 (representing less than a 10 percent increase in average door-to-door trip time), about 130,000 barrels per day of petroleum could be saved now (based on 1977 fuel consumption data), and by the year 2000 about 380,000 barrels per day could be saved.

This change could be implemented with a less than 10 percent increase in new aircraft cost. However, the significant operating costs savings would rapidly pay back any increase in aircraft cost and represent a major cost savings for an airline. Net savings result in fuel prices above 20-30 cents per gallon, considerably below current jet fuel prices.

A new aircraft fuel economy standard, with an in-use fleet phase in over 20 years, is recommended to assure realization of the full fuel savings potential. Congressional authority would be necessary to impose such standards.

If the average value of the extra flight time for passengers and crew is considered at 10 dollars per hour per person, the total "cost" of the fuel saved through this initiative is 25 cents per gallon.

Background

Aircraft (excluding military) consumed 8.3 percent of the total transportation energy in 1977 and are projected to consume 16 percent of the transportation energy by the year 2000. Aircraft are totally dependent on petroleum energy. In 1977 aircraft petroleum consumption was equivalent to about 820,000 barrels per day. Aircraft are projected to consume 2,350,000 barrels per day by the year 2000. Commercial aircraft consume about 90 percent of the aviation fuel.

Commercial aircraft consume almost twice the energy per passenger mile as compared to automobiles, about 2 to 3 times as much energy per passenger mile as trains, and about 6 times more energy per passenger mile than buses. Long haul aircraft are operating about 1/3 more fuel efficient (Btu/passenger-mile) than short haul aircraft. Yet, over half the commercial seat miles are flown by aircraft on trips of less than 1,000 miles. Aircraft flying trips of less than 1,000 miles consume about 330,000 barrels per day (1977), and for trips of less than 700 miles consume about 234,000 barrels per day of petroleum.

Even though aircraft are the most energy inefficient means of passenger transport, air is the fastest growing transportation mode. The reason for this is simple. Air is by far the fastest mode of transportation, and many people value very much the time saved as compared to other forms of transportation.

Fuel Conservation Potential

At a given speed and weight, an aircraft will obtain its optimum fuel efficiency at a particular altitude. The optimum cruise altitude increases as fuel is consumed. The optimum speed and altitude will depend on the aircraft and engine design. (For example, a turbo-prop powered aircraft is more efficient at lower speeds and lower altitudes than a turbo-fan powered aircraft.) For conventional turbo-fan powered aircraft, the fuel efficiency increases significantly with increasing trip length since the energy consumed in take-off, climbing, terminal maneuvering and landing becomes a less significant factor. The large, wide-bodied aircraft with high by-pass ratio engines are more efficient than the smaller, narrowbodied, low by-pass ratio configurations. Most long range aircraft have peak fuel efficiencies in the 1,500 to 4,000 miles range.

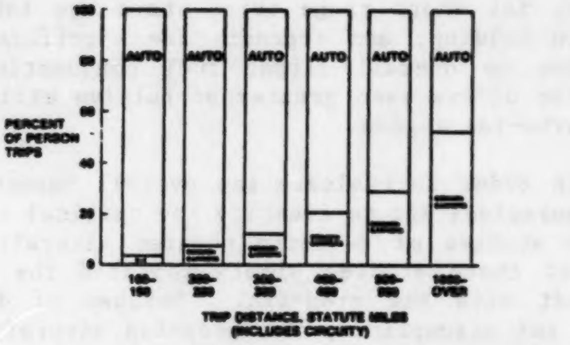
In 1977, aircraft carried about 12 percent of the total intercity passenger travel while automobiles carried about 86 percent. As trip length increases however, aircraft's share of intercity passenger travel increases. For trip lengths over 1,000 miles, aircraft carry over 50 percent of all passengers.1/ (See Figure 1.) For these long distance trips, the competing transportation modes are aircraft and automobiles. For these trip lengths, at current load factors, aircraft are performing passenger transport with about the same energy efficiency (Btu/passenger mile) as current automobiles.

This initiative will concentrate on improving the efficiency of aircraft which can be used primarily for trips of less than 1,000 miles because: (1) there is significant research directed at improving the efficiency of long range, high speed aircraft, (2) the commercial aircraft industry has a strong market inspired drive to incorporate such improved technologies into the fleet as rapidly as possible, (3) current design aircraft have peak fuel efficiencies above 1,000 mile trip ranges, and (4) significant potential appears to exist to improve the fuel efficiency of shorter range aircraft which may not be developed or utilized.

The potential for 50 percent or more fuel savings from lower-speed, new-technology turbo-prop aircraft exists as compared to the aircraft currently serving the short/medium haul markets (the DC9, the B-737, and B-727 aircraft).2/3/4/ If the aircraft is designed for minimum fuel usage, the optimum cruise speed is about Mach 0.7 (current aircraft cruise between 0.8 and 0.85), with a straight wing and a wing aspect ratio over 15.

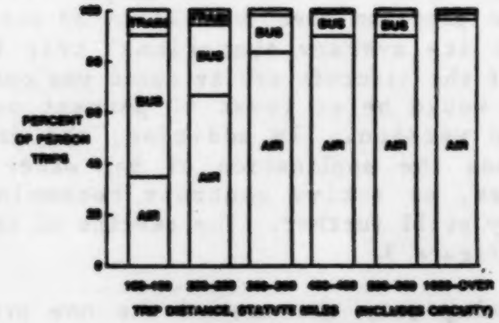
Consideration of energy efficiency necessitates a re-examination of the turbo-prop powered aircraft - not the 1950s version,

FIGURE 1a*



Percent of Trips by Major Mode Versus Range (1972)

FIGURE 1b*



Percent of Trips by Common Carrier Versus Distance (1972)

*Source "Fuels Outlook I - Transportation and the U.S. Petroleum Resource, An Aviation Perspective" by M. P. Miller and R. A. Mays, American Institute of Aeronautics and Astronautics, N.Y., February 1978.

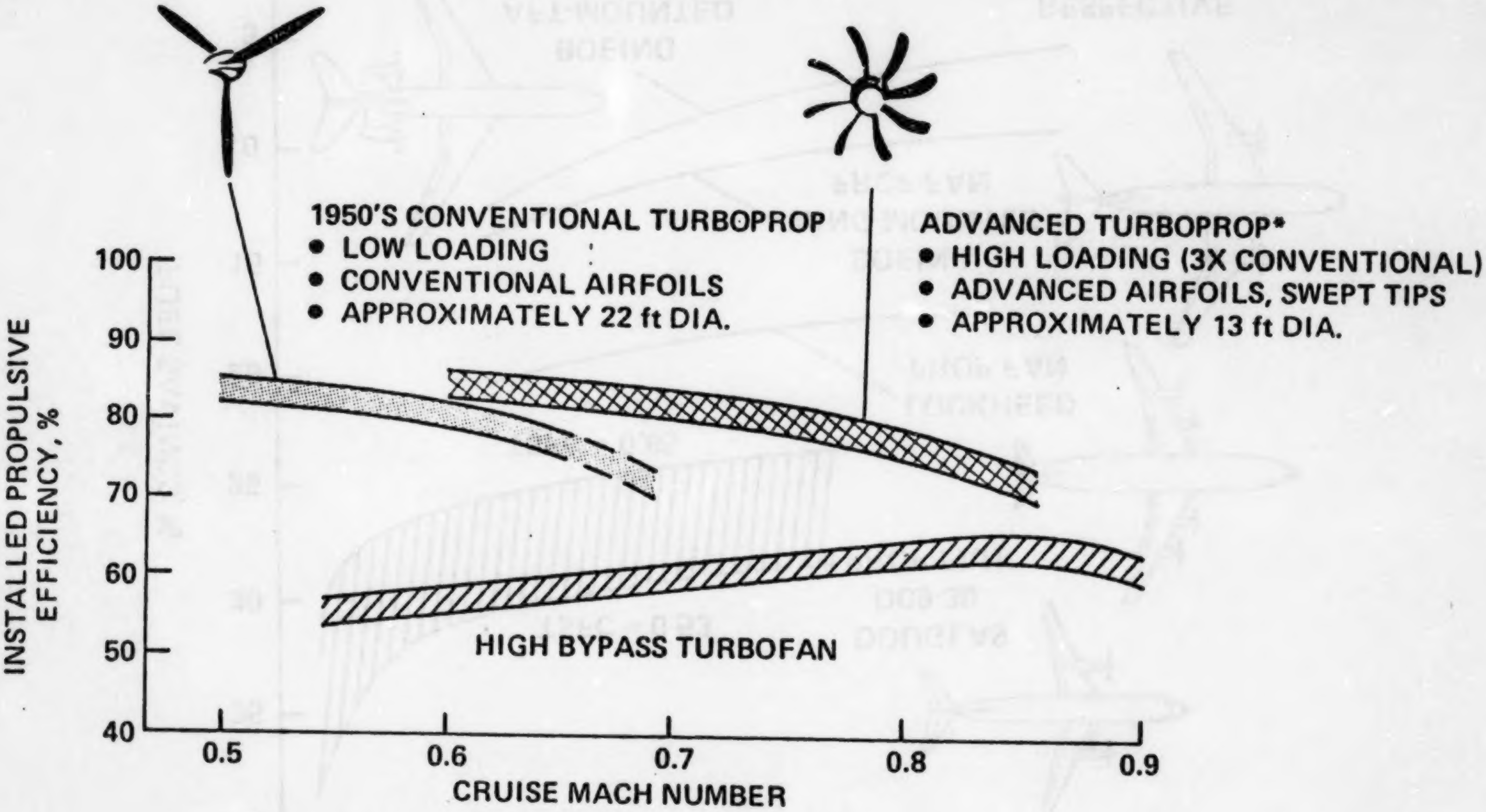
but a new highly loaded multi-bladed turbo-prop using advanced blade structure and aerodynamics technology for efficient, high-speed operation. Because the concept lies somewhat between the conventional turbo-prop and an unshrouded high by-pass ratio turbo-fan, such a turbo-prop design is often referred to as the prop-fan. Wind tunnel testing (see Figure 2) shows the propulsive efficiency of the advanced prop-fan to be about 20 percent better (at Mach 0.8) than a high by-pass ratio turbo-fan of similar engine technology.2/ The efficiency advantage improves at lower speeds, increasing to 30 to 40 percent at a cruise speed of Mach 0.7. Of course, for short range trips where the take-off, climb, landing pattern holding, and approach are significant modes of operation relative to overall flight fuel consumption, the turbo-prop or prop-fan offers even greater propulsive efficiency advantages over the turbo-fan engine.

In order to evaluate the overall impact on complete aircraft configurations and to identify the critical technology areas, three design studies of prop-fan powered aircraft have been completed. Each of these studies simply replaced the turbo-fan on existing aircraft with the prop-fan. Because of different study ground rules and assumptions, the prop-fan aircraft fuel savings identified in these three studies range from 8 to 28 percent in comparison with their turbo-fan counterparts for a 1,000 nautical miles trip length at a cruise speed of Mach 0.8 (see Figure 3).

In all cases, the increased efficiency advantages of the prop-fan compared to the turbo-fan at lower altitudes and speeds resulted in greater fuel savings at shorter trip lengths. The largest fuel savings of the three studies were for a prop-fan derivative of the DC9-30 investigated by the Douglas Aircraft Company.5/

Depending on the assumed propulsion system efficiency, the derivative prop-fan uses from 27 to 33 percent less fuel than the DC9-30 at its average operational trip length of 290 nautical miles. If the aircraft cruise speed was optimized at Mach 0.7, the aircraft would be at least 40 percent more efficient than the turbo-fan version. In addition, the prop-fan derivative did not include the application of any other advanced aerodynamics, structures, or active controls technologies that can improve efficiency still further. The results of the other two studies are shown on Figure 3.

Assuming only the use of the new prop-fan technology which could begin service by 1990, it is reasonable to expect a 40 percent reduction in fuel consumption as compared to the same technology turbo-fan, with the prop-fan powered aircraft cruising at Mach 0.7 and the turbo-fan powered aircraft cruising at Mach 0.85 and averaged over all commercial trips of less than 1,000 miles in length. If commercial air trips of less than 1,000 miles in length are flown with the new prop-fan technology aircraft at Mach 0.7 rather than the same technology aircraft in turbo-fan



PROPULSIVE EFFICIENCY

*PROJECTION BASED ON 1976 MODEL WIND TUNNEL TESTS

FIGURE 2

PROP-FAN AIRCRAFT FUEL SAVINGS

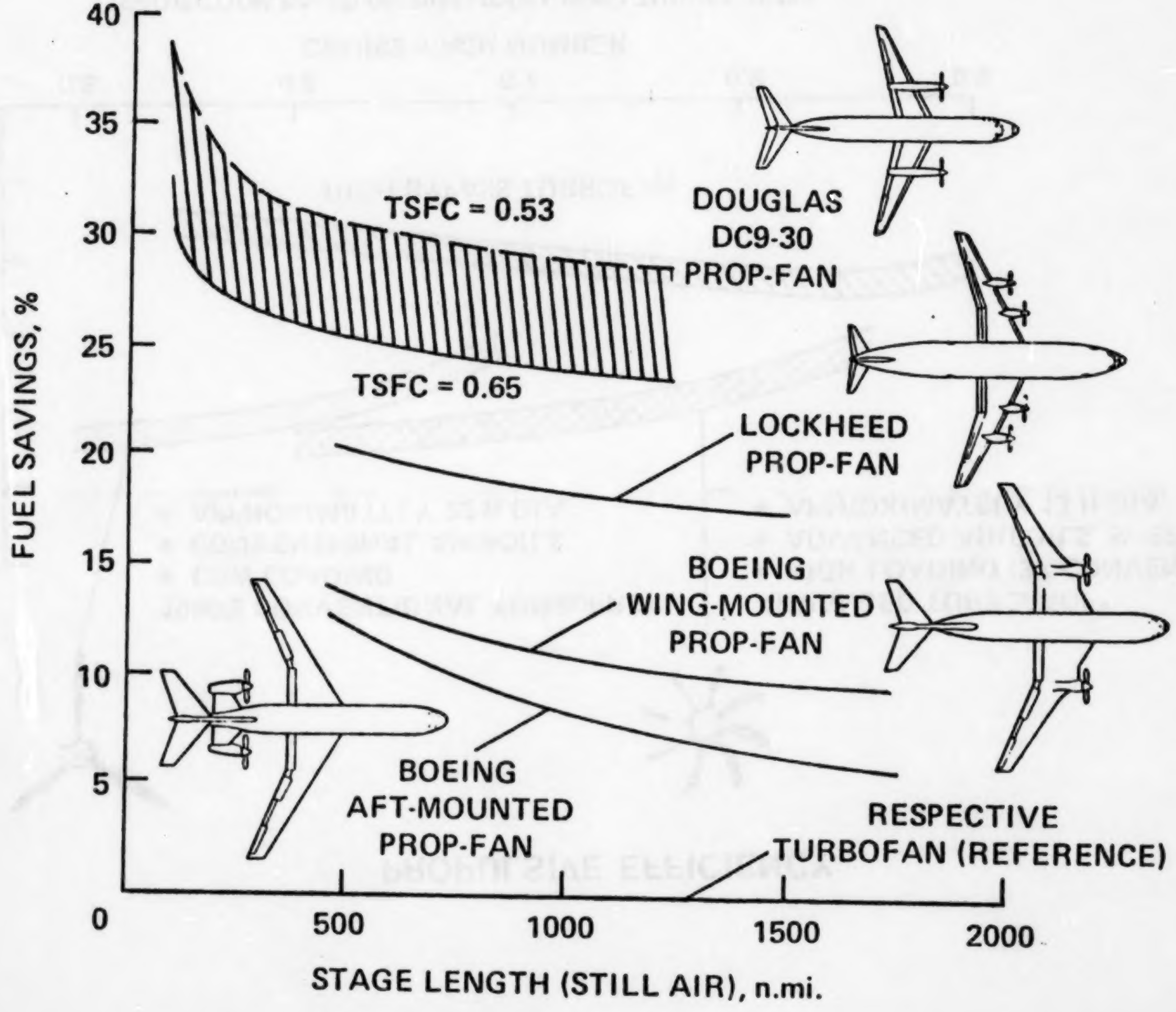


FIGURE 3

aircraft flying at Mach 0.85 as is currently done, then about 130,000 barrels/day of petroleum could be saved based on 1977 fuel consumption figures, and by the year 2000 about 380,000 barrels/day could be saved. When considering trips of 700 miles length and less, about 270,000 barrels/day could be saved by the year 2000.

Cost to Implement

In the previously referenced study by Douglas Aircraft Company which studied a prop-fan version of the DC9-30, the prop-fan airplane had a total fly away cost estimated to be 12 percent higher than for the turbo-fan aircraft. This was primarily due to an increased cost associated with the engine and the extra cost of the gear boxes and prop-fans. With the cost comparison in 1973 dollars, the DC9-30 turbo-fan aircraft was 5.68 million dollars as compared to the prop-fan version which would cost 6.34 million dollars. The direct operating costs savings were calculated to be 9 to 10 percent with fuel cost assumed at 60 cents/gallon. Possible maintenance benefits were also projected but their dollar worth was not calculated or credited. With such substantial direct operating costs savings even at the Mach 0.8 design-study speed, the slightly higher inital aircraft cost is very rapidly neutralized. Assuming aviation fuel at 60 cents/gallon, direct operating costs of $2.00/nautical mile and 2,000 nautical miles per day, the annual operating costs of the DC9-30 would be 1.46 million dollars. A 10 percent reduction in direct operating costs would produce $146,000/per year savings. This reduction in annual operating costs would be compared against the expected increased initial purchase price of the aircraft of $660,000, giving a pay-back period of less than 10 years (even at fuel costs of 60 cents/gallon) for a 30 year useful life aircraft.

In a letter to Charles Gray, U.S. EPA dated February 6, 1980, Lewis J. Williams of the Ames Research Center, National Aeronautics and Space Administration states: "In terms of the potential for improvements in future advanced turbo-prop powered transport aircraft specifically designed for short-haul operation at a cruise speed of about Mach 0.7 it appears that fuel savings of 30 to 50 percent and operating cost savings of 20 to 30 percent (depending on fuel costs) could be achieved relative to current jet transport aircraft without a substantial increase in aircraft initial cost." With the possibility of no significant increase in initial aircraft cost and operating cost savings as high as 30 percent, DC9-30 operation as assumed above could save almost a half million dollars per year per aircraft.

Since the question, how much will each gallon of fuel "generated" through conservation "cost", is often asked of a new idea, the following analysis attempts to provide a reasonable perspective on the answer. If the following example is used:

1. A Dallas, Texas to Washington, D.C. flight of approximately 1000 nautical miles and lasting about 2.5 hours.

2. Baseline aircraft B727-200 with 132 seats and 0.303 miles per gallon fuel economy.

3. Future Prop-Fan Aircraft with 132 seats and 0.53 miles per gallon fuel economy.

4. Average per plane price increase of 500,000 dollars.

5. Each plane flies on average of 2,000 nautical miles per day over a 30 year useful life period.

6. Average load factor of 0.56 and 5 person crew.

7. Fifteen percent overall flight time increase.

8. Twenty-five dollars per hour average value of extra flight time per person.

Then the results are:

1. 1410 gallons of fuel are saved over the flight.

2. Considering the time value of money, about 5 cents per nautical mile is the increased cost of the new aircraft.

3. For 79 people on board, 30 hours of "extra" time is generated at a "cost" of about 75 cents per nautical mile.

4. The total "cost" of the saved fuel is 57 cents per gallon.

Since many passengers work on board the plane, some sleep, some time is spent eating meals, some passengers relax and socialize, and some may simply be going on vacation, it may be inappropriate to value the extra flight time at an average of 25 dollars per hour. If 10 dollars per hour is used as a more appropriate average, the "cost" of the fuel saved becomes about 25 cents per gallon.

Supply of the New Technology

The commercial aviation industry is an industry of rapidly changing technology. There should be no problem in providing the required new prop-fan technology to meet full production demand.

Wind tunnel testing of model prop-fans has been conducted since 1976 by United Technologies. Beginning in the second half of 1980, NASA will establish the fabrication feasibility and structural integrity of large-scale propellers in the 8 to 10 feet diameter range. Work in subsequent years will include the fabrication of the large-scale propeller, experimental engine tests and airplane flight demonstrations.6/ From the results of NASA's Phase I effort (the extensive small-scale high-speed propeller technology development), commercialization of the prop-fan is not risky from a technology standpoint, but it will take time to carry it through final aircraft optimization.7/ The time to commercialization is largely a function of the priority that remaining work receives, and if sufficient priority exists, commercial introduction by 1990 seems reasonable. However, it should be noted that such an airplane has not yet been built or the projected performance "proven."

Impacts

This initiative should not result in any negative economic impacts. The engine manufacturing industry is not likely to have a negative economic impact, either in an absolute sense or on a disproportional basis. The engine manufacturer who would have produced the turbo-fan engine is likely also to produce the prop-fan engine for the aircraft. The air frame manufacturer will have to install a different type engine on his air frame, however, this should not represent a negative impact. The airline industry should derive substantial economic benefits in terms of reduced operating costs. Aircraft passengers should receive savings passed on by the airlines.

There is no reason to expect any negative environmental, safety or other negative impacts. Indeed, a reduction in aircraft noise appears likely.

Three "impacts" deserve special consideration however. These are: (1) the passenger psychological acceptance of a propeller driven aircraft, (2) the increased travel time associated with flying at a slightly slower speed, and (3) the question of what to do with the aircraft which might be displaced from active service due to an accelerated introduction of the more fuel efficient prop-fan powered aircraft.

Many in the flying public remember the early period in the air transport industry where prop engine aircraft were dominant. Those initial aircraft were often noisy, slow and had vibration problems. With the coming of the jet age in the early 1960s and the modernization of commericial aircraft as we know them today, some people may consider the return to a propeller type engine as offensive. However, the new aircraft should not suffer in terms of actual passenger discomforts relative to turbo-fan powered aircraft. Public awareness efforts to characterize these new engines as advanced technology will go a long way toward removing the potential stigma of old technology.

Since most people fly aircraft for the reduction in time necessary to get from one place to another, flying in the lower speed prop-fans may be considered a major drawback. In particular the airlines may be very reluctant to, on their own initiative, procure these slower speed aircraft when their competitors may continue to purchase the traditional high speed aircraft. However, when one considers the actual increase in travel time which would result from such new prop-fan aircraft, the passenger sacrifice is not so great. In reducing the speed from Mach 0.84 to Mach 0.7, a cruise speed reduction of about 17 percent results. Two typical trips from actual origin to final destination will be considered - first, a typical short-haul trip from downtown Washington, D. C. to downtown New York City and a typical medium-haul trip from Chicago to New York City.8/

The trips include all the additional transportation time required to commute from the downtown office to the common carrier terminal and wait for departure. For the Washington, D.C. to New York City trip, a 2 and 3/4 hours trip is assumed with a flight time of one hour. For the Chicago to New York City trip, the door to door time is about 4 hours with a flight time of about one hour and 50 minutes. Even assuming that the 17 percent reduction in cruise speed also applies for the overall flight (it would actually be less due to the much better efficiencies of the prop-fan during the non-cruise flight modes), the Washington to New York flight would be increased by 10 minutes or 6 percent; the Chicago to New York trip would be increased about 19 minutes or about 8 percent. Since both of these flights represent very "tight" connections, the actual delays would likely result in a smaller percent increase in overall trip time. In any case, most travellers would probably agree that a 10 to 20 minute increase in travel time or less than 10 percent increase in overall origin to destination time would not be an unreasonable hardship.

The question of what to do with aircraft that might be displaced from the short-haul trips they are now serving (before they would normally be retired) is a difficult one. As was discussed earlier, most of the aircraft that would be displaced (the Boeing 737 and 727 aircraft and the McDonnell Douglas DC9) have their peak fuel efficiencies in the 1,000 to 2,000 mile trip length range. Also, as these aircraft have lower seat capacity than the new wide-body aircraft that might otherwise serve this market, the smaller aircraft would likely be more fuel efficient than the wide-body aircraft on many of these routes because they can operate with higher load factors and are operating at their optimum trip length efficiency. Thus, the displacement of these aircraft might very well allow a reoptimization of the aircraft-to-trip-served market to maximize fuel efficiency. (See Figure 4.)

As Figures 5 and 6 show, the trips between 1,000 and 2,000 miles in length represent about 26 percent of the total fuel consumed. As can also be seen, this market is also served to a significant extent already (almost 50 percent) by Boeing 727 aircraft. Thus, an optimum arrangement might indeed be to have three basic categories of aircraft satisfying the domestic and international travel needs; prop-fan aircraft serving predominantly the less than 1,000 miles trips, the Boeing 727 type aircraft serving predominantly the 1,000 to 2,000 mile trip lengths, and the wide-bodied aircraft serving predominantly the trip lengths of greater than 2,000 miles.

AIRCRAFT ENERGY EFFICIENCY VERSUS STAGE LENGTH AIRLINE OPERATION, INCREASED DENSITY SEATING

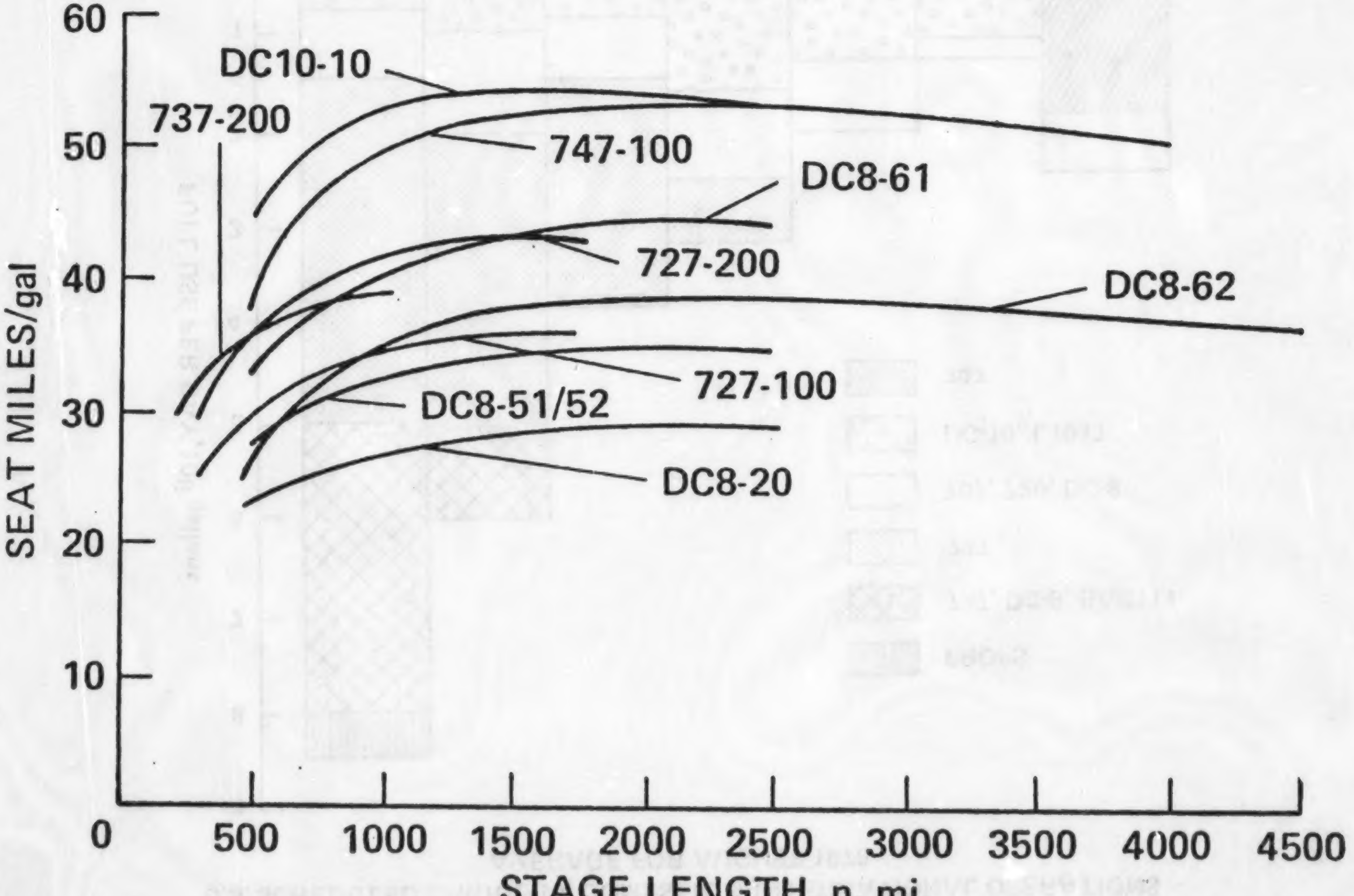
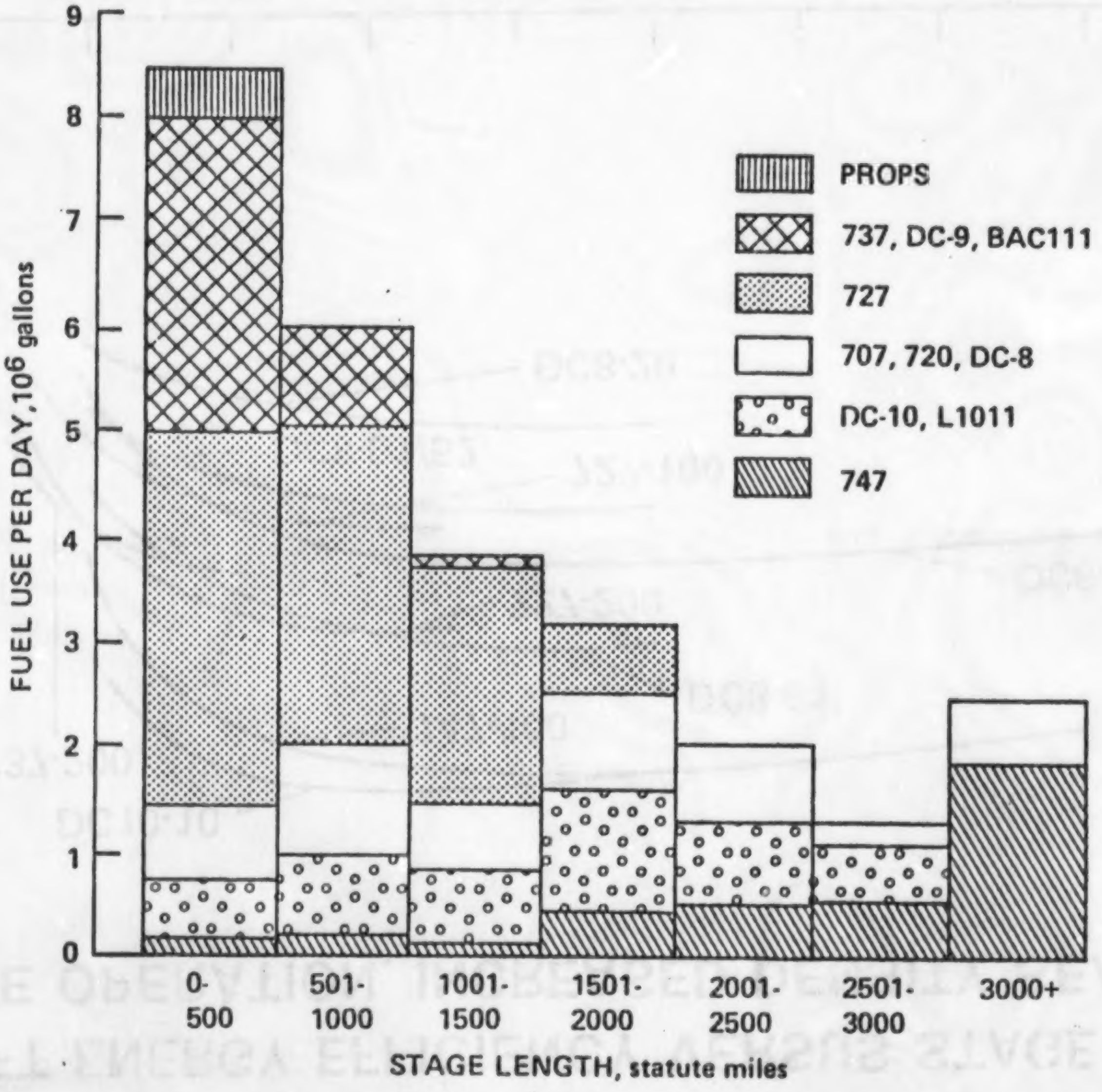


FIGURE 4

AIRCRAFT FUEL USAGE

U.S. SCHEDULED CARRIERS, DOMESTIC & INTERNATIONAL OPERATIONS
AVERAGE FOR AUGUST 1976



AIRCRAFT FUEL USE DISTRIBUTION

U.S. SCHEDULED CARRIERS, DOMESTIC & INTERNATIONAL OPERATIONS
AVERAGE FOR AUGUST 1976

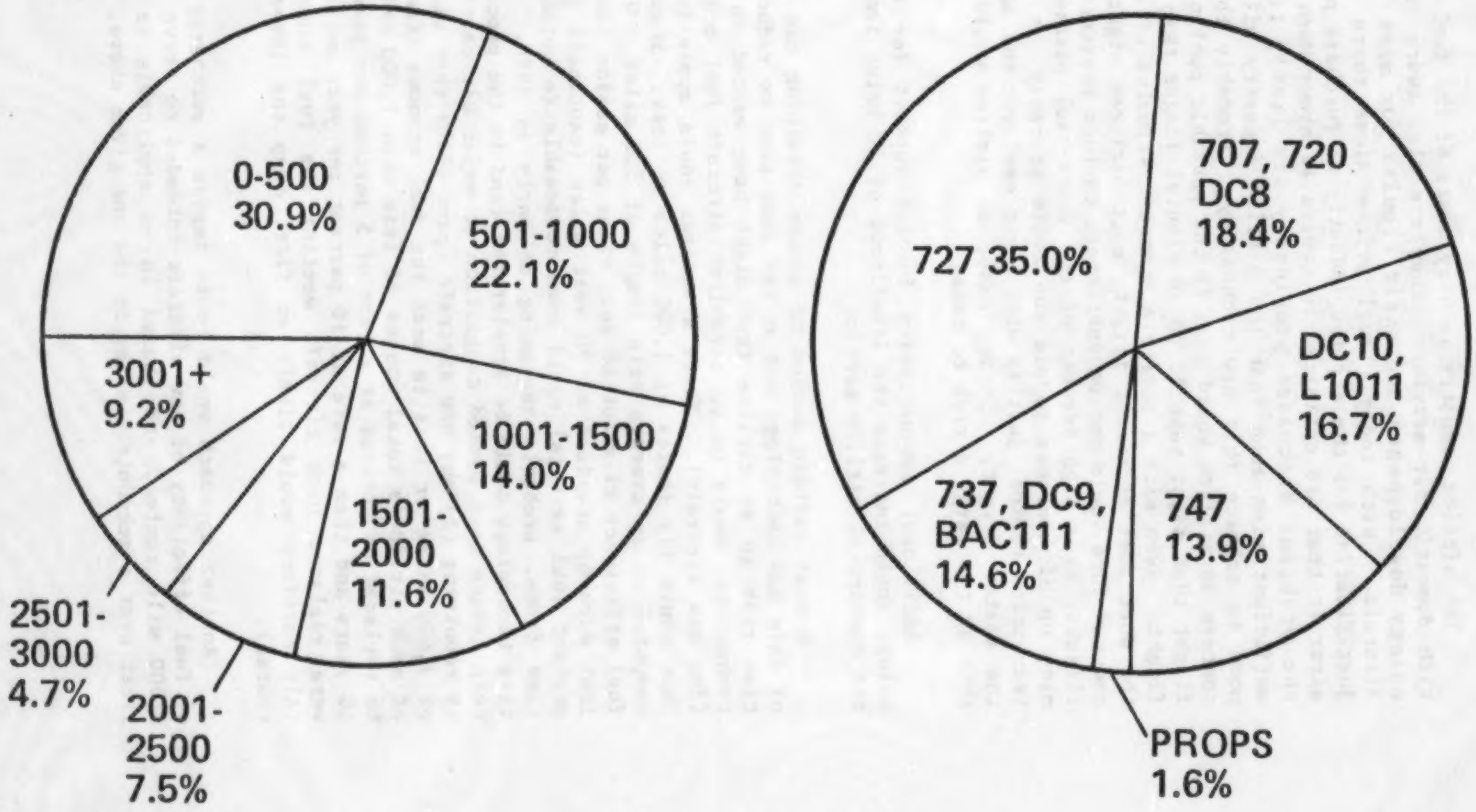


FIGURE 6

Implementation Options

The airline industry is very aware of the fuel cost associated with domestic air service. They are also aware of the new technology developments and their promise for more fuel efficient aircraft. With today's fuel prices alone there is an economic justification for the airline industry to purchase prop-fan powered aircraft that are optimized to cruise at about Mach 0.7. However, the problems discussed previously are likely to be viewed as sufficient risk such that the airline industry will not make the move to embrace this new technology. Probably the most serious concern an airline would have is the possible public rejection of a flight that might take 10 to 20 minutes longer than a competitor's flight. Even with a possible economic stimulus of lower fares for the more fuel efficient flight, most airlines might feel that the reduced fare would not be sufficient to lure passengers from faster flights, as a high percent of the short-haul passenger traffic is made up of business people who could probably, at least during a transition period, justify with their employer the added expense of the faster flight. In any case, an airline would probably view this as too large a risk to take.

Additional demonstration funding support for this new technology would increase the likelihood of it being incorporated into the commercial airline service.

A most certain method to assure attaining the full potential of this new technology and at the same time to reduce the competitive risk to an airline that might have wanted to introduce the technology, would be to establish aircraft fuel economy standards (for new aircraft). These standards could apply to all aircraft that would fly routes of 1,000 miles or less. Standards could be computed on an average trip length of 500 miles. With a baseline fuel efficiency of about 40 seat miles per gallon (see Figure 7), a fuel economy standard of 70 seat miles (nautical) per gallon (43 percent fuel savings) would seem reasonable to obtain in the 1990 time frame, probably beginning as early as 1990. The effect of this technology could be accelerated (and in the process would also help reduce peak period congestion at major air carrier terminals) by requiring (1) any new aircraft (past 1990) that will serve trips of 1,000 miles or less to meet the fuel economy standard, and (2) of each airline's total routes of less than 1,000 miles, routes to be replaced or retired at a rate of 5 percent per year for the next 10 years and then a rate of 10 percent per year until all aircraft were replaced with aircraft meeting the fuel economy standard. (Air carriers would likely at first drop the lower load factor routes).

Another approach would be to impose a surcharge on the basis of fuel efficiency of new aircraft intended to serve the less than 1,000 mile routes, and phased in as applicable to the existing fleet over a schedule similar to the one given above.

AIRCRAFT ENERGY EFFICIENCY – DERIVATIVES & NEW AIRCRAFT
AIRLINE OPERATION, 1000 n. mi. STAGE LENGTH

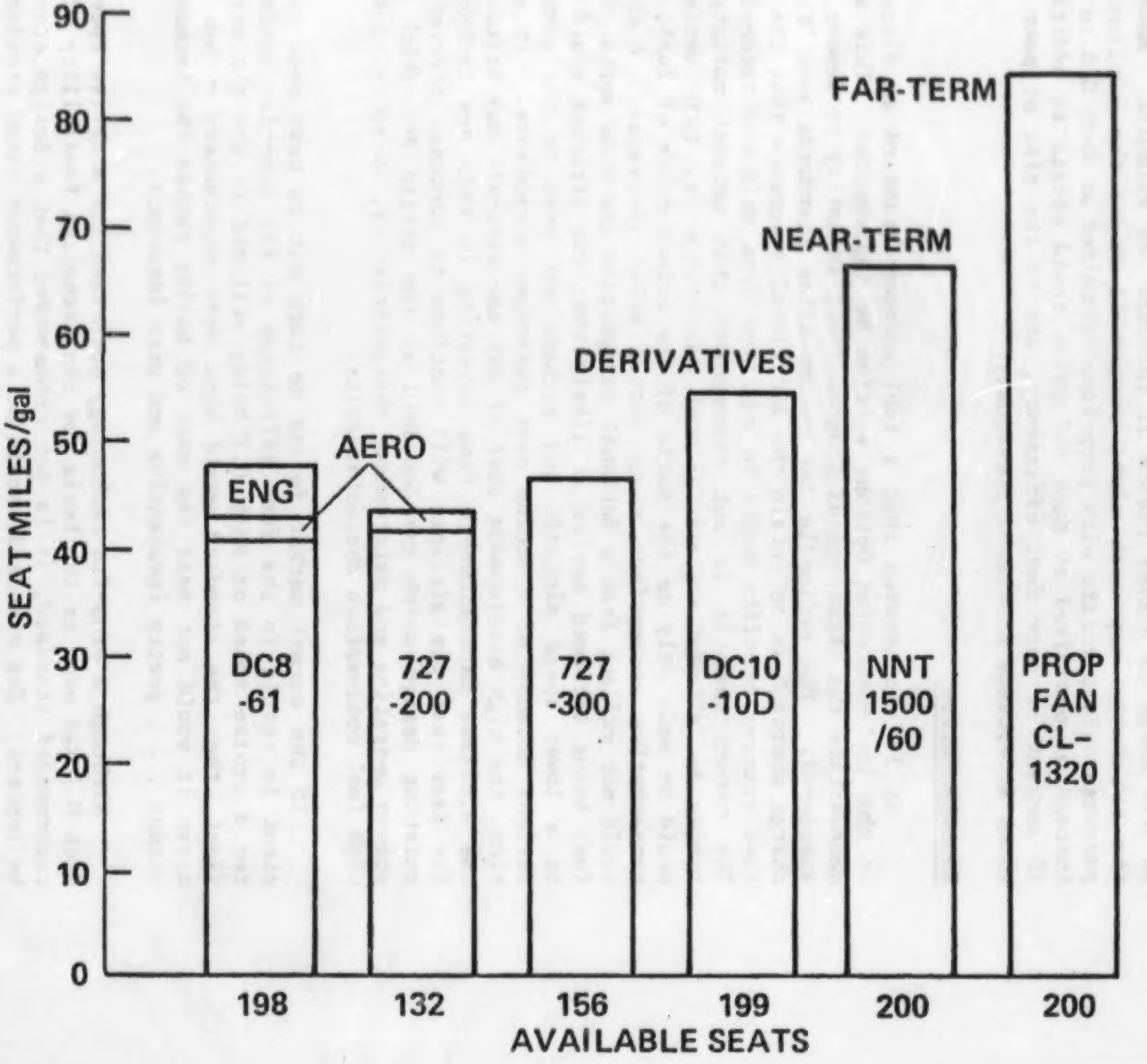


FIGURE 7

The surcharge could be structured such that for every seat mile per gallon that the aircraft was under the seat mile per gallon target, the airline would pay $.01 per mile traveled by that aircraft. An aircraft with a fuel economy of 50 seat miles per gallon would pay $.20 per mile traveled by that aircraft; this would represent about a 10 percent increase in the direct operating cost to the aircraft. Of course, higher or lower surcharges could be considered to either reduce or increase the stimulus. However, the surcharge approach might very well drive the airlines to purchase only aircraft with prop-fans optimized at Mach 0.8 to 0.84 instead of optimized at Mach 0.7 which could obtain an additional 10 percent or more fuel efficiency, due to the risk of poor consumer acceptance discussed previously.

Recommendation

It is recommended that a fuel economy standard as discussed in the Implementation Options section be implemented. This would necessitate the obtaining of Congressional authority to impose such standards. The rationale for recommending standards over a surcharge approach is to obtain the additional assurance that the full fuel economy benefits would be realized from this new technology. The reason that it is not recommended that natural marketplace forces be allowed to act without assistance is, that decisions would be made only on the basis of the actual price of fuel, with conservative assumptions about future price increases. Also, it would not reflect from a National perspective the true worth of the fuel being consumed nor is it likely that the airlines would move to a lower speed aircraft and perhaps not even to the prop-fan designs because of concerns over passenger acceptance. In addition, the high development cost of any new aircraft may discourage the airframe manufacturers from investing in this new technology for fear that the airlines will continue to purchase aircraft of existing design which can be sold at the margin and which have proven operating and maintenance characteristics, in spite of their high fuel consumption characteristics.

If the normal market forces do turn out to have been sufficient to result in the fuel efficiency of the prop-fan optimized for a cruise speed of Mach 0.7 being utilized in the air carrier fleet, then the standard would have been unnecessary - but then again it would not bear the cost of having pushed the technology change . . . pretty inexpensive and wise insurance.

Although a prop-fan technology optimized for a cruise speed of Mach 0.7 was used as the basis for the technical feasibility of the recommended standard, it is not recommended that a design standard be imposed. The standard should be a performance based standard as discussed in the Implementation Options section, with the industry left to respond with designs of any type that meet the standards.

References

1/ Fuels Outlook I - Transportation in the U.S. Petroleum Resource, An Aviation Perspective by M.P. Miller and R.A. Mays, American Institute of Aeronautics and Aerostronautics, N.Y. February, 1978.

2/ Williams, Lewis J., "Air Transportation Energy Efficiency," Presented at the Fourth National Conference on the Effects of Energy Constraints on Transportation Systems, August, 1977.

3/ Letter from Lewis J. Williams, National Aeronautics and Space Administration, Ames Research Center, to Charles Gray, U.S. EPA, February, 1980.

4 Personal correspondence with Dick Webber, Chief of Mission Analysis Office, Lewis Research Center, National Aeronautics and Space Administration, January, 1980.

5/ Kraus, E.F. and Van Abkoude, J.C., "Cost/Benefit Trade-Offs for Reducing the Energy consumption of the Commercial Air Transportation System," Douglas Aircraft Company, Report for the National Aeronautics and Space Administration, June, 1976.

6/ Olstad, Walter B., Statement of National Aeronautics and Space Administration before the Subcommittee on Transportation, Aviation and Communications of the Committee on Science and Technology, U.S. House of Representatives, February 6, 1980.

7/ Personal communication with Lewis J. Williams, National Aeronautics and Space Administration, Ames Research Center, April 4, 1980.

8/ Mascy, Alfred C. and Williams, Lewis J., "Air Transportation Energy Consumption: Yesterday, Today, and Tomorrow," American Institute of Aeronautics and Astronautics paper 75-319, February 1975.

Highway Vehicles

Highway vehicles are by far the largest consumer of petroleum in the United States. About 78 percent of the transportation energy is consumed by highway vehicles. Although buses and motorcycles are classified as highway vehicles, their energy consumption is small (about 1 percent) relative to automobiles and trucks. Because the major consuming modes are automobiles and trucks and because these highway vehicles offer the greatest potential for improved energy efficiency, the new initiatives developed in this section will focus on these vehicles.

There are several highway vehicle energy conservation programs currently underway. Perhaps the most significant of these is the Corporate Average Fuel Economy standards for automobiles and light trucks. There are also several public information initiatives currently being implemented by the Department of Energy, the Department of Transportation, and the Environmental Protection Agency. These include such things as the EPA/DOE Gas Mileage Guides, driver energy conservation training programs, and driver feed-back devices. However, in this most crucial energy consuming sector, there is really little underway beyond the Corporate Average Fuel Economy standards which will effect significant energy conservation. Even the Corporate Average Fuel Economy standards will not have their greatest effect until the 1990s when vehicles that can achieve the 1985 standards have largely displaced the existing energy consuming fleet.

As highway vehicles represent by far the largest petroleum consuming sector in this country, much of the effort in this study has been expended to identify and develop new conservation initiatives in this area. Several new initiatives have been developed. These initiatives range from additional and improved public information programs to very major changes in the automobile and our views regarding personal transportation. The initiatives focus both on the existing in-use fleet of vehicles as well as energy conservation initiatives that effect the new vehicles.

The commercial trucking industry is a relatively sophisticated, cost-conscious industry. While fuel efficiency has in the past been considered in the design of commercial trucks, it has now become a major design goal for new trucks. Several alternative methods for increasing the energy efficiency of new commercial trucks are available. These include improved engines, power trains, tires, aerodynamics, auxiliary components, lubricating oils, operating procedures, and reduced vehicle weight. The commercial trucking industry, faced with rising operating costs of which fuel costs are a significant fraction, has responded to market pressures and begun wide ranging initiatives to decrease total fuel usage. Fuel economy information dissemination should be continued by the Federal government as is currently being performed by the Federal Voluntary Truck and Bus Fuel Economy Program. Heavy-duty engine fuel efficiencies as measured by a standardized procedure should be added to the information disseminated through the Federal program. The Federal emission certification tests provide a ready source of such engine fuel efficiency data. Further, the Interstate Commerce Commission regulations which sometimes encourage trucks to return from delivery trips empty should be revised. Due to the growing significance of fuel costs and the technical sophistication in industry in regards to energy conservation measures, it is expected that significant additional progress in increasing the energy efficiency of the commercial trucking industry will be made as a result of normal market pressures. The commercial truck conservation initiatives discussed in this section are those which may not otherwise be implemented if left to market forces alone (the fuel economy labeling of tires and engine oils to allow the market forces to work properly, and reduced speed limits for interstate highway commercial truck travel).

The first group of initiatives deals with fuel savings which can be obtained through strategies involving the highway speed limit (Enforcement of 55 MPH National Speed Limit, Fuel Savings from Better Enforcement and/or Lowering of Heavy-Duty Vehicle Speed Limit, Increased Speed Limits for More Fuel Efficient Cars on Interstate Highways).

The next group of initiatives involves approaches to improving the operating efficiency of the existing fleet of vehicles. Two initiatives (Low-Energy Dissipation Tires for Automobiles and Light Trucks and Low-Energy Dissipation Tires for Heavy-Duty Trucks) are designed to reduce the energy required to propel the vehicle by lowering the rolling resistance of the tires. One initiative is designed to lower the internal resistance of moving parts with the engine (Fuel Efficient Engine Oils). Another initiative would increase the thermodynamic efficiency of the engine (Improved Engine Efficiency Through Cylinder Deactivation). The next initiative is designed to assure that each vehicle is operating at the proper state of tune (A Fuel Economy Check-up to Assure Proper Fuel Economy Maintenance). The next initiative is designed to convince the public that the government is serious about the need for energy conservation (An Energy Conservation Example Should Be Set by the Federal Fleet).

The last two initiatives are designed to assure that new highway vehicles are as fuel efficient as practicable, considering factors such as technological feasibility, economics and satisfying the basic market needs (More Stringent Enforcement of the Corporate Average Fuel Economy Standards, More Stringent and/or Restructured Fuel Economy Levels for Automobiles and Light Trucks).

Enforcement of 55 MPH National Speed Limit

Summary

This initiative reduces nationwide fuel consumption by eliminating the fuel penalty associated with vehicle travel in excess of 55 mph. This excess fuel is estimated to be 98,000 barrels per day, based on 1977 highway speed survey statistics.

If a value of 5 dollars per hour per person is placed on the extra time necessary to travel at 55 mph rather than some higher speed, then the "cost" of the fuel saved is about $6.70 per gallon.

This initiative will probably impact the enforcement sector (principally state highway patrols), state revenues (through increased assessment of speeding fines), the driving public (through slightly increased travel times--and decreased accident/fatality rates), insurance disbursement and possibly insurance rates (also due to decreased accidents and mortality), and traffic court case loads.

No additional statutory or regulatory authority is necessary to implement this initiative.

Background

The degree of violation of the national 55 mph speed limit has been comprehensively surveyed and reported by the U.S. Department of Transportation.1/ For example, 74 percent of VMT on U.S. rural interstates in 1977 was traveled in excess of 55 mph. DOT has also reported2/ on accident and mortality rates associated with vehicle speed.

High speed on the highways results in decreased vehicle fuel economy, and in wasted fuel for each mile traveled. The recent EPA "404 Report"3/ shows that optimum fuel economy occurs at cruise speeds of 30 to 40 mph, and fuel economy drops steadily at higher cruise speeds. The mpg penalty at 80 mph is on the order of 40 percent compared to the optimum.

Fuel Conservation Potential

A thorough treatment of this issue involves a state-by-state study, since motor fuel usage, vehicle miles traveled, and speed limit abuse all vary considerably among the states. Not unexpectedly, the states whose travel is the most fuel- and VMT-intensive are also the ones whose speed abuses are, in the aggregate, the most flagrant. Taken as two groups, the 25 highest and 25 lowest fuel consuming states have the characteristics shown on Table 1, from the DOT data.

The fuel consumption implications of each state's speeding

Table 1

Fuel Use, VMT, and Speeding Characteristics, 1977

	"Top 25" States	"Bottom 25" States	Total U.S.
Total Motor Gasoline Used (10^9 gallons)	89	19	108
Total VMT (10^{12} miles, all vehicles)	1.22	0.26	1.48
% of VMT on Rural Roads	0.41	0.58	0.44
% of Rural Interstate VMT > 55 mph	78%	61%	74%

pattern were computed on the basis of VMT fractions in 5 mph speed bands, and relative VMT among urban and nonurban roads, from the DOT data; and assumed mpg penalties (relative to 55 mph) of 2 percent for 55-60 mph travel, 6 percent for 60-65 mph travel, and 12 percent for travel in excess of 65 mph. The detailed calculation results are voluminous, so they have been condensed into Table 2. While use of the rural Interstates' speed patterns for the computation would appear to overestimate excess fuel usage, the speed patterns for other road types are not drastically different from the rural Interstates, and VMT traveled on urban highways has not been included in the computations.

Figure 1 illustrates state-by-state and cumulative fuel waste from Table 2.

The total potential fuel savings of 100 percent enforcement of the 55 mph speed limit are seen from the above to be approximately 1.5 billion gallons per year, based on speeding patterns measured in 1977. Since the speed patterns of vehicle travel are largely up to individual drivers, voluntary speed reductions in response to other pressures such as fuel shortages and rising fuel prices could lessen the necessity of, or payoff from, a fuel saving initiative based exclusively on speed limit enforcement. That is, the fuel savings could happen without the initiative; however, there is no way of assuring these results except through enforcement.

Cost to Implement

Detailed implementation costs have not been estimated for this initiative. No additional laws or regulations are required, so there is no cost for enactment. It is not known whether the law enforcement sector will necessarily incur added net cost (over and above additional revenues from speeding fines) due to more diligent enforcement efforts. The truck transportation industry is not expected to lose money due to reduced ton-miles hauled per unit time, due to reduced fuel costs per mile and per ton-mile.

If a value is placed on the extra time necessary to travel at 55 mph rather than some higher speed, then a "cost" of the fuel saved can be calculated. Using the following example:

1. Current average speed of 58 mph,
2. Current fuel economy of 16 mpg,
3. An average occupancy per car of 2.6 people,
4. A time value of 5 dollars per hour per person,
5. A one percent fuel economy improvement per mph speed decrease;

then at 55 mph, the fuel saved would "cost" about $6.70 per gallon. However, the improved safety associated with the 55 mph average speed will have dollar value associated with it that will at least partially reduce the "cost" per gallon. Higher or lower time-values will also directly affect the calculated cost.

Table 2

Effects of Highway Speeding on Fuel Consumption, by State

			Million Gallons/ Year Excess Fuel	
State	% Rural Interstate VMT Exceeding 55 mph	% Excess Highway Fuel Usage	State	Cumulative
Texas	84%	5.7%	151	151
California	82%	4.5%	96	247
Georgia	84%	5.2%	79	326
Pennsylvania	81%	4.2%	78	404
N. Carolina	89%	4.3%	67	471
Ohio	77%	3.7%	66	537
New York	75%	3.9%	54	591
Virginia	80%	4.4%	51	642
Missouri	90%	4.8%	50	692
Tennessee	83%	5.0%	49	741
Illinois	80%	3.9%	48	789
Florida	78%	4.0%	47	836
Michigan	72%	3.4%	44	880
Indiana	81%	4.4%	43	923
Kentucky	80%	4.8%	43	966
Alabama	76%	4.5%	42	1008
Oklahoma	81%	5.1%	37	1045
Wisconsin	81%	3.5%	35	1080
Iowa	72%	2.9%	24	1104
Maryland	70%	3.5%	23	1127
Minnesota	66%	2.6%	23	1150
Louisiana	46%	1.6%	17	1167
Washington	69%	2.7%	16	1183
New Jersey	57%	2.0%	12	1195
Massachusetts	70%	3.6%	11	1206
Subtotal, Top 25	78%	4.2%	1206	
Other 25	61%	2.7%	246	
Total U.S.	74%	3.8%	1452	

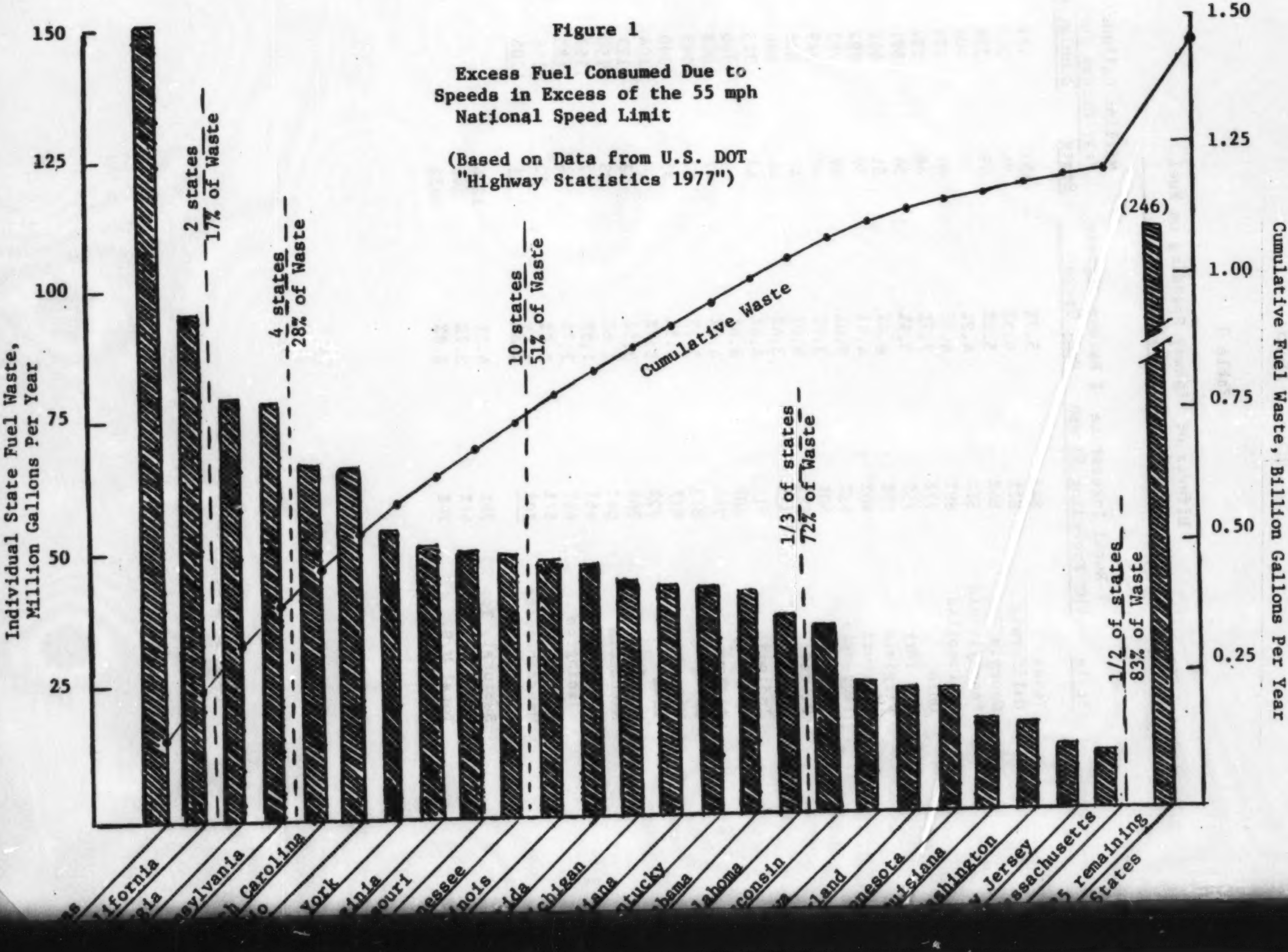


Figure 1

Excess Fuel Consumed Due to Speeds in Excess of the 55 mph National Speed Limit

(Based on Data from U.S. DOT "Highway Statistics 1977")

Technology Availability

Not applicable.

Impacts

As discussed earlier, two impacts are certain: slightly increased travel times, and reduced highway accidents and injuries/death. To put travel time increase in perspective, the added "time penalty" for slowing from 65 mph to 55 mph is as follows:

Increased Travel Time, 55 mph vs. 65 mph

10-mile trip:	2 minutes
30-mile trip:	5 minutes
200-mile trip:	34 minutes
1,000-mile trip:	168 minutes

The enforcement sector will be impacted either through the addition of personnel or diversion of some existing personnel from other duties. The probability of increased court case loads and assessment of speeding fines is obvious.

Another potential impact may be a travel mode shift, wherein long-distance travelers in a hurry choose aircraft travel in lieu of driving, due to increased driving times. For example, in a 1978 study conducted for the Department of Energy, it was concluded that, "the savings resulting from the lower speed limit (from 55 to 50 mph) is nearly eliminated by shifts to air."4/

Implementation Options

With the possible exceptions of voluntary driver compliance with the national speed limit due to fuel supply and price pressures, this initiative is deemed achievable only by means of enforcement of existing laws.

Recommendation

The national 55 mph speed limit should be enforced.

There are several techniques available to the states to improve compliance with the 55 mph speed limit. The two most apparent are; 1) significantly increase the speeding fines, or 2) revocation of drivers' licenses for repeated offenders. Consideration, however, should be given to adjusting the federal highway funds allocations on the basis of a state's success in achieving compliance with the 55 mph speed limit. States with average speeds above 55 mph would receive a smaller share of highway funds. For example, the federal share would go down 5 points for every mph over 55 (for a state with an average speed of 60 mph, the federal funding share would drop 25 percent). Such an approach should

eliminate much of the difficulty of implementing a "we will withhold your funds if you don't comply" type approach.

References

1/ U.S. Department of Transportation, "Highway Statistics 1977," Report FHwA-HP-HS-77, 1978.

2/ U.S. Department of Transportation, "55 MPH Fact Book," 1978.

3/ U.S. Environmental Protection Agency, "Passenger Car Fuel Economy: EPA and Road" ("404 Report"), April 1980.

4/ Modal Shifts in Short-Haul Passenger Travel and the Consequent Energy Impacts, Report of the United Technologies Research Center for the Department of Energy, March 1978.

Fuel Savings from Better Enforcement and/or Lowering of Heavy-Duty Vehicle Speed Limit

Summary

This initiative examines the fuel conservation potential available from strict enforcement of the 55 mph speed limit for heavy-duty freight vehicles and from three different scenarios involving lower speed limits for heavy trucks.

It is recommended that the speed limit for heavy-duty vehicles on multi-lane highways be reduced to 45 mph, while maintaining the 55 mph speed limit on two-lane highways. Both sets of speed limits would need to be aggressively enforced, and Congressional legislation would be required to mandate the 45 mph speed limit. The withholding of highway construction funds from states refusing to enact and enforce the 45 mph speed limit would have to be emphasized and a vigorous public information campaign undertaken. Strict enforcement of the dual speed limits would result in the savings of 141,000 barrels of oil per day based on 1977 consumption, and a savings of 185,000 barrels of oil per day in 1985 based on growth projections. Other positive impacts include a probable slight reduction in fatalities from accidents involving heavy trucks and a slight reduction in overall truck air and noise pollution. The primary negative impact would be slightly longer delivery times for most intercity freight shipments.

If a value of 20 dollars per hour is placed on the extra time necessary to travel at 43 mph rather than at 58 mph, then the "cost" of the fuel saved is about $2.10 per gallon.

Background

A. Heavy-Duty Vehicle Fuel Consumption Which Would be Affected

Heavy-duty vehicles are a major link in our freight hauling system. In 1977, heavy trucks accounted for about 24 percent of the total intercity freight ton-miles traveled, while rail, pipeline, water, and air accounted for 35.7 percent, 24.2 percent, 16.1 percent, and 0.2 percent of the total freight ton-miles, respectively.1/ While heavy-duty vehicles accounted for less than one-quarter of the freight ton-miles traveled, they accounted for over one-half of the energy consumed by the freight hauling industry.1/ 2/ This conservation initiative considers the fuel savings which are possible due to the better enforcement of, and the lowering of, the maximum speed limit for heavy-duty freight trucks. As such, fuel savings will only be possible for those trucks which are operated near or above the present maximum speed limit of 55 mph. Unfortunately, it has not been possible to locate information specifying exactly the fuel consumption of heavy-duty vehicles in operation at speeds of 55 mph or greater. It has been possible to determine the fuel consumption and energy used by all trucks in 1977, broken into categories of "single unit" trucks and "combination" trucks. For the following reasons it seems fairly valid to assume that the fuel consumption of "combination" trucks approximates the fuel consumption of heavy-duty trucks in operation at 55 mph or greater. First, and rather obvious, "combination" trucks refer to the tractor/trailor type of trucks while "single unit" trucks refer to trucks built from a single chassis body. The former are used almost exclusively for intercity freight movement, and thus are driven predominantly on free-flowing interstate highways, while the latter are used primarily for personal use (pickup trucks), which would not be affected by the lower speed limit, and for intracity freight movements (larger single-body trucks) which seldom reach speeds of 50 mph. The single-unit fuel consumption is reported to be all gasoline, which confirms the previous assumptions, as practically all pickup and intracity freight trucks are currently gasoline-powered. The "combination" truck fuel is all reported as distillate fuel oil, which again confirms our expectations as practically all intercity freight trucks utilize the more fuel-efficient diesel engine. Second, data from one other reference, which breaks truck fuel consumption down into "intercity" and "local", but which does so only for 1973, 1980, 1985, and 1990, generally verifies our assumption. The "intercity" fuel consumption in that report for classes 6, 7, and 8 for 1973 approximates the "combination" fuel consumption given in the Data Book for 1974.3/ For these reasons, it appears fairly valid to use the fuel consumption of "combination" trucks as equivalent to the fuel consumption of "heavy-duty trucks at speeds equivalent to or in excess of 55 mph." It is recognized that combination trucks clearly are not always driven at 55 mph or greater, for example, while in urban areas at the beginning and end of trips. But it is also clear that many of the single-unit, gasoline-powered heavy-duty vehicles, whose fuel consumption is not included in the "combination" category, are sometimes operated at 55 mph or greater speeds and our assumption will ignore these fuel savings. These two qualifications must be noted, but probably counter-balance each other around 55 mph. At the lower speed scenarios of 45 mph and 30 mph, our assumption of affected fuel consumption is likely too low as less of the "combination" fuel consumption would be at operation less than those speeds and greater amounts of the "single unit" fuel consumption would be at speeds greater than the maximum limits. Thus, the fuel consumption of heavy-duty vehicles which would be affected by greater enforcement or lowering of speed limits will be taken as 764,000 barrels of fuel per day as of 1977.4/

Of the total energy consumed by the transportation industry in 1977, 8.4 percent was consumed by heavy-duty vehicles which would be affected by this initiative. And the heavy-duty freight industry is a growing industry. It has increased its share of the freight market from 16.3 percent in 1950 to 21.3 percent in 1970 to 23.9 percent in 1977. Projections vary, but it is estimated that without conservation measures the total ton-miles carried by heavy-duty vehicles will increase by approximately 3.4 percent per year from 1975 through 2000, while total transportation energy use will increase 1.6 percent per year in the same time period.5/ If the 3.4 percent growth per year estimate of ton-miles is accepted, and assuming that fuel consumption grows at the same rate, by 1985 heavy-duty freight trucks will consume the equivalent of 998,000 barrels of distillate fuel oil daily and by the year 2000 will consume about 1,770,000 barrels per day.

B. Average Speed of Intercity Heavy-Duty Vehicles

The fuel consumption benefits that can be derived from better enforcement or a lowering of the maximum heavy-duty vehicle speed limit are dependent to a large degree on the current speeds of heavy-duty vehicles. We have two pieces of information that is relevant to this question. The Federal Highway Administration yearly reports data from state certification reports on average free flow speed on various types of highways. Their 1978 data (reported in the 1978 Highway Statistics) reported the average free flowing speed of all motor vehicles on rural interstate highways to be 58.8 mph. This data does not discern between freight trucks and passenger cars. To investigate the question of the speed of trucks compared to passenger vehicles, the National Highway Traffic Safety Administration initiated a special speed monitoring survey in late summer/early fall 1978. This survey reported the average free flowing speed of heavy trucks to be 58.3 mph.6/ Based on these data, and on the fact that rural interstate cruising speeds are generally higher than cruising speeds on non-interstate highways, we will assume that 58 mph is the average heavy-duty vehicle speed for those vehicles which would be affected by this conservation initiative.

C. Effect of Speed on Intercity Heavy-Duty Vehicle Fuel Consumption

It is well accepted that vehicle speed has an important effect on heavy-duty vehicle fuel consumption. Theoretically, the effect is fairly easy to understand. There are two primary resistances which must be overcome to move a large truck at constant speed: 1) rolling resistance, or the energy needed to roll the tires, and 2) air resistance, or the energy needed to displace the air as the truck moves down its path. The rolling resistance is directly proportional to the mass of the truck plus payload and directly proportional to vehicle speed. Air resistance, however, increases as the cube of the vehicle speed. Thus, at low vehicle speeds, the rolling resistance is the primary force to be overcome in vehicle motion. But as velocity increases, air resistance becomes more important, and at high vehicle speeds (55-60 mph) air resistance actually becomes the dominant resistance.7/ At low speeds, where rolling resistance dominates, fuel consumption only increases at approximately the same rate as the vehicle speed, but at higher speeds, where air resistance becomes important, fuel consumption due to air resistance increases as the cube of the speed increase, and so overall fuel economy deteriorates fairly rapidly.

A literature search was undertaken to accurately delineate the effect of lower speed limits and lower average speeds on heavy-duty vehicle fuel consumption. The results from the literature search are shown in Tables 1 and 2.

Fuel Conservation Potential

It should be clear from the previous discussion and from Tables 1 and 2 that lower speed limits and lower average speeds reduce the fuel consumption of heavy-duty vehicles. While the maximum speed limit is the parameter over which the government can have the most direct control, the speed-related parameter which most directly affects fuel consumption is actual vehicle speed. For the purposes of this initiative, average vehicle speed will be used to typify actual vehicle speed.

Four different scenarios affecting actual heavy-duty vehicle speeds will be examined: 1) strict enforcement of the 55 mph speed limit (as opposed to the de facto 60-65 mph speed limit as presently enforced), 2) a lowering of the maximum speed limit on all roads for heavy-duty vehicles to 45 mph, 3) imposition of the 45 mph speed limit for heavy trucks on multi-lane highways only with a 55 mph speed limit on two-lane highways, and 4) a lowering of the speed limit to 30 mph for heavy-duty vehicles on all roads.

A. Strict Enforcement of the Current 55 mph Speed Limit

It should be clear to anyone who has driven on the interstate system in recent years that the 55 mph speed limit, enacted to save fuel, has never been strictly enforced. Rather, most states and enforcement agencies have enforced "real" speed limits in the range of 60 to 65 mph. Thus, strict enforcement of the 55 mph speed limit could lower average heavy-duty vehicle speeds and fuel consumption as well.

As stated earlier, while the speed limit is the one parameter over which the government can exert control, it is actual (average) vehicle speed that affects fuel consumption. We have already estimated that the average speed of heavy-duty vehicles now in use in intercity traffic is 58 mph. It is necessary to estimate the average speed of heavy-duty vehicles under the scenario where the 55 mph speed limit would be strictly enforced. We know of no studies reporting such data, but clearly the average speed would be less than 55 mph. How much less depends on many factors such as

Table 1

Effect of Speed Limit and Average Speed (in 45 to 65 mph Range) on Heavy-Duty Vehicle Fuel Consumption

Source/Conditions	ΔSL*(mph)	ΔAS*(mph)	%Δ FC *(gallons/100 miles)	%Δ FC/mph SL	%Δ FC/mph AS
Broderick, DOT (2 to 4 trips each, 1975 9/					
Detroit Diesel, 28,000 lb. payload, short and hilly route	60-55	50.8-48.8	9.6%	1.9%	4.8%
Detroit Diesel, 28,000 lb. payload, short and hilly route	55-50	48.8-45.4	3.5%	0.7%	1.0%
Detroit Diesel, 28,000 lb. payload, long, grade route	60-55	49.9-47.7	2.2%	0.4%	1.0%
Detroit Diesel, 28,000 lb. payload, long, grade route	55-50	47.7-44.6	3.8%	0.8%	1.2%
Detroit Diesel, 42,000 lb. payload, short and hilly route	60-55	49.4-45.5	11.4%	2.3%	2.9%
Detroit Diesel, 42,000 lb. payload, short and hilly route	55-50	45.5-44.3	2.0%	0.4%	1.7%
Detroit Diesel, 42,000 lb. payload, long, grade route	60-55	47.8-45.6	2.7%	0.5%	1.2%
Detroit Diesel, 42,000 lb. payload, long, grade route	55-50	45.6-44.4	0.7%	0.1%	0.6%
Average				0.9%	1.8%
Cummins/Exxon, 1974 10/					
Cummins NTC-350, 65,000 lb.	none-65	64.7-60.4	11.5%	-	2.7%
Cummins NTC-350, 65,000 lb.	65-60	60.4-56.9	5.7%	1.1%	1.6%
Cummins NTC-290, 65,000 lb.	none-60	59.5-56.9	7.7%	-	3.0%
Cummins NTC-290, 65,000 lb.	60-55	56.9-52.0	6.5%	1.3%	1.3%
Cummins Super 250, 65,000 lb.	none-55	54.9-50.9	7.2%	-	1.8%
Cummins Super 250, 65,000 lb.	55-50	50.9-47.1	4.9%	1.0%	1.3%
Average				1.1%	2.0%

continued next page

Table 1 (cont.)

Source/Conditions	Δ SL(mph)	Δ AS(mph)	%Δ FC $\frac{\text{(gallons)}}{\text{(100 miles)}}$	%Δ FC/mph	
				SL	AS
DOT, 1979 (computer simulations by industry)11/					
Detroit Diesel 6V-92TTA, 65,000 lb. route #1	65-60	55.2-53.1	4.8%	1.0%	2.3%
Detroit Diesel 6V-92TTA, 65,000 lb. route #1	60-55	53.1-49.5	6.2%	1.2%	1.7%
Detroit Diesel 6V-92TTA, 60,000 lb. route #1	65-60	55.9-53.5	5.4%	1.1%	2.3%
Detroit Diesel 6V-92TTA, 60,000 lb. route #1	60-55	53.5-49.8	6.7%	1.3%	1.8%
Detroit Diesel 6V-92TTA, 65,000 lb. route #2	65-60	50.2-48.4	3.0%	0.6%	1.7%
Detroit Diesel 6V-92TTA, 65,000 lb. route #2	60-55	48.4-45.8	3.5%	0.7%	1.3%
Detroit Diesel 6V-92TTA, 60,000 lb. route #2	65-60	51.4-49.6	3.1%	0.6%	1.7%
Detroit Diesel 6V-92TTA, 60,000 lb. route #2	60-55	49.6-46.8	4.1%	0.8%	1.5%
Cummins, Formula 290, 65,000 lb.	65-55	58.6-53.1	13.1%	1.3%	2.4%
Average				1.0%	1.9%
DOT, 1979, Average of 32 trucks optimized for best (on-track) fuel economy at 55 and 65 mph12/		65.0-55.0	22.0%		2.2%

---

*SL - speed limit
AS - average speed
FC - fuel consumption

Table 2

Effect of Speed Limit and Average Speed (in 25-55 mph Range) on Heavy-Duty Vehicle Fuel Consumption

Source/Conditions	Δ SL*(mph)	Δ AS*(mph)	%Δ FC* (gallons)/(100 miles)	%Δ FC/mph SL	%Δ FC/mph AS
EPA, 1976, average of 12 diesel trucks fully loaded, steady-state dynamometer tests13/	-	55-30	33.6%	-	1.3%
Marlok, 1976, engineering model14/					
One truck, two 40 ft. trailers, 0 lb., 0 grade	-	55-25	51.5%	-	1.7%
One truck, two 40 ft. trailers, 0 lb., 1.5% grade	-	55-25	32.5%	-	1.1%
One truck, two 40 ft. trailers, 60,000 lb., 0 grade	-	55-25	30.8%	-	1.3%
One truck, two 40 ft. trailers, 60,000 lb., 1.5% grade	-	55-25	20.9%	-	0.7%
One truck, two 40 ft. trailers, 100,000 lb., 0 grade	-	55-25	34.8%	-	1.2%
One truck, two 40 ft. trailers, 100,000 lb., 1.5% grade	-	55-25	18.0%	-	0.6%
One truck, one 40 ft. trailer, 0 lb., 0 grade	-	55-25	60.4%	-	2.0%
One truck, one 40 ft. trailer, 0 lb., 1.5% grade	-	55-25	43.1%	-	1.4%
One truck, one 40 ft. trailer, 60,000 lb., 0 grade	-	55-25	48.1%	-	1.6%
One truck, one 40 ft. trailer, 60,000 lb., 1.5% grade	-	55-25	29.1%	-	1.0%
One truck, one 40 ft. trailer, 100,000 lb., 0 grade	-	55-25	43.4%	-	1.4%
One truck, one 40 ft. trailer, 100,000 lb., 1.5% grade	-	55-25	24.7%	-	0.8%
One truck, two 27 ft. trailers, 0 lb., 0 grade	-	55-25	56.4%	-	1.9%
One truck, two 27 ft. trailers, 0 lb., 1.5% grade	-	55-25	38.0%	-	1.3%

continued next page

Table 2 (cont.)

Source/Conditions	Δ SL(mph)	Δ AS(mph)	%Δ FC $\frac{\text{(gallons)}}{\text{(100 miles)}}$	%Δ FC/mph SL	%Δ FC/mph AS
One truck, two 27 ft. trailers, 60,000 lb., 0 grade	-	55-25	46.1%	-	1.5%
One truck, two 27 ft. trailers, 60,000 lb., 1.5% grade	-	55-25	27.2%	-	0.9%
One truck, two 27 ft. trailers, 100,000 lb., 0 grade	-	55-25	42.0%	-	1.4%
One truck, two 27 ft. trailers, 100,000 lb., 1.5% grade	-	55-25	23.5%	-	0.8%
Average					1.3%

---

*SL - speed limit
AS - average speed
FC - fuel consumption

the severity of the penalty for exceeding 55 mph, the amount of effort expended by and the expertise of police in enforcing the speed limit, traffic congestion, etc. Our estimate is that the average speed of heavy-duty vehicles under strict enforcement of the 55 mph speed limit would be approximately 53 mph. Thus, simply enforcing the 55 mph speed limit for heavy-duty vehicles would lower their average speeds by 5 mph (58-53 mph). What would this mean in terms of fuel consumption?

Table 1 lists the relevant data pertaining to the effect of average speed on heavy-duty vehicle fuel consumption for speeds in the range of 45 to 65 mph. The average values for the fuel consumption drop per mile-per-hour average speed decrease from each study were: 1.8 percent, 2.0 percent, 1.9 percent, and 2.2 percent. These data agree very well and it can be fairly confidently estimated that the fuel consumption savings for vehicles at these speeds would be approximately 2.0 percent per mile-per-hour average speed decrease. Hypothesizing a 5 mph drop in average speed results in a fuel savings of 10 percent for heavy-duty vehicles. Recalling that heavy-duty vehicles affected by this initiative consumed 764,000 barrels of fuel per day in 1977, this would result in a fuel savings of 76,000 barrels of fuel per day as of 1977. Given the growth expected in the trucking industry and assuming no further conservation measures, strict enforcement of the 55 mph speed limit for heavy-duty vehicles would save 100,000 barrels of fuel daily by 1985.

B. Lowering of Heavy-Duty Vehicle Speed Limit to 45 mph

Even greater fuel savings could be achieved by lowering the heavy-duty vehicle speed limit to 45 mph and enforcing it at 45 mph on all types of roads. Our estimate is that the average speed of heavy-duty vehicles affected would then be about 43 mph, resulting in a 15 mph drop from the current situation and a 10 mph drop from the scenario involving strict enforcement of the 55 mph speed limit (see above).

It was concluded in the previous section that the data in Table 1 show that for average speeds in the 45 to 65 mph range, fuel consumption drops 2.0 percent per mile-per-hour average speed decrease. This resulted in a 10 percent fuel savings at an average speed of 53 mph. The lowering of the average speed from 53 mph to 43 mph will result in additional fuel savings, but likely not at a rate of 2.0 percent per mile-per-hour. The data shown in Table 2 for speed changes from 55 mph down to 25-30 mph show a fuel savings of only about 1.3 percent per mile-per-hour average speed. The reduction in speed from 53 mph to 43 mph is somewhere in the middle of the data in Tables 1 and 2, but nearer the data in Table 1. Thus, the fuel savings realized from lowering the average speed of heavy-duty vehicles from 53 mph to 43 mph will be assumed to be 1.7 percent per mile-per-hour decrease in average speed, or an additional 17 percent fuel savings over that derived from enforcement of the 55 mph speed limit. Thus, a 45 mph speed limit for heavy-duty vehicles on all types of highways could save 10 percent plus 17 percent or 27 percent of the fuel presently consumed by heavy-duty intercity vehicles. This would result in a fuel savings of 206,000 barrels of fuel per day as of 1977 and 269,000 barrels of oil per day by 1985 (expected growth and no further conservation measures).

C. Lowering of Heavy-Duty Vehicle Speed Limit to 45 mph on Multi-Lane Highways Only

The previous section examined the fuel conservation potential of an enforced 45 mph speed limit on all highways. Because of possible congestion and safety problems on two-lane highways under a scenario where freight trucks would have a 45 mph speed limit and passenger vehicles would have a 55 mph speed limit, it is also worth considering the scenario where trucks would be subject to the 45 mph speed limit only on those highways which could handle the speed limit differential without causing significant congestion or safety problems. Highways which could best handle such a speed differential are multi-lane highways. These are primarily interstate highways, but would also include other multi-lane highways which are not part of the interstate highway system. From Federal Highway Administration data for vehicle-miles-travelled for "combination" trucks (i.e., intercity freight trucks), it appears that approximately 50 percent of the intercity freight traffic is on multi-lane highways (all of the interstate traffic and a fraction of the "other main rural" traffic).8/ Thus, if the 45 mph speed limit were enforced only on multi-lane highways, the fuel savings would be approximately 50 percent of the additional fuel savings calculated in the previous section for a universal 45 mph speed limit, or 8.5 percent. The total fuel savings would be that from better enforcement of the 55 mph speed limit (10 percent) plus that from the implementation and enforcement of a 45 mph speed limit for heavy trucks on multi-lane highways (8.5 percent), or 18.5 percent. This would result in a fuel savings of 141,000 barrels of fuel per day as of 1977 and 185,000 barrels of oil per day by 1985 (assuming no further conservation measures).

D. Lowering of Heavy-Duty Vehicle Speed Limit to 30 mph

Additional fuel savings would occur if the heavy-duty vehicle speed limit were lowered to 30 mph. It is estimated that the average speed for heavy-duty vehicles would then be 29 mph. Thus, we are now considering the fuel savings to be derived from a lowering of the average heavy-duty vehicle speed from 58 mph to 29 mph. We have no data encompassing the whole interval from 58 mph to 29 mph. But we have already determined that lowering the average speed of heavy-duty vehicles from 58 mph to 53 mph would reduce their fuel consumption by 10 percent. This leaves us with the question of how much fuel would be saved by reducing the speed further from 53 mph to 29 mph. This range corresponds almost perfectly with the speed ranges in Table 2. From those data it seems clear that the reduction in speed from 53 mph to 29 mph should reduce fuel consumption by 1.3 percent per mile per hour, or by an additional 31.2 percent. Thus, from the current situation, the setting and enforcing of a 30 mph speed limit for heavy-duty vehicles would reduce the fuel consumption by 41.2 percent. This would conserve 315,000 barrels of oil daily as of 1977 consumption and 411,000 barrels of oil daily based on 1985 consumption estimates (assuming no further conservation measures).

Table 3 summarizes the above fuel conservation potentials, showing the fuel savings for the four speed limit scenarios outlined above, both in terms of incremental fuel savings and cumulative fuel savings.

Cost to Implement

A. Government Implementation Cost

There are three enforcement parameters which influence the probability that a truck driver will exceed the speed limit. One is simply the attitude of the individual truck driver and truck owner with respect to the seriousness of the law enforcement agency in enforcing the speed limit, a second is the probability that the truck driver will be "caught" and penalized, and the third is the severity of the penalty. Thus, the three most obvious strategies that the government could utilize to ensure that heavy-duty trucks were complying with the speed limit would be 1) to make clear through both words and deeds that the law enforcement agencies throughout the nation intend to seriously and accurately enforce the speed limit, 2) to expend more resources on surveillance and enforcement and 3) to promulgate much more severe penalties for violators.

Of these three strategies, only the second would involve substantial governmental resources (more police, police cars, surveillance equipment, etc.). The first and third strategies would cost very little, and, in our opinion, could be quite effective. Simply the realization by truck drivers and owners that police personnel were no longer going to "look the other way" if they witnessed a truck exceeding the speed limit by "only 2 or 3 mph" would go a long way towards forcing them to lower their vehicle speeds. In the end, truck drivers and owners will probably still turn to an economic analysis to decide their vehicle speed patterns. And some drivers may conclude that they can "beat the system," that an occasional small fine is offset by the slightly reduced trip times, or that the cost savings due to better fuel economy is not enough to offset the fixed labor costs or depreciation costs. To discourage this sort of determination (whether acurate or not), we recommend a stronger monetary penalty

Table 3

Summary of Fuel Conservation Potential

Speed limit (mph)	--	55	45 on rural multi-lane/ 55 elsewhere	45 everywhere	30 everywhere
Average speed (mph)	58	53	43/53	43	29
% Incremental Fuel Savings	--	10%	8.5%	8.5%	14.2%
% Cumulative Fuel Savings	--	10%	18.5%	27%	41.2%
Cumulative Savings as of 1977 (bbl/day)	--	76,000	141,000	206,000	315,000
Cumulative Savings Based on 1985 projections (bbl/day)	--	100,000	185,000	269,000	411,000

for violators. To be considered is the possibility of a fairly stringent point-system whereby a truck owner who consistently violates the speed limit could lose his (or her) licenses. We are confident that a strong national law enforcement commitment combined with a set of more severe monetary penalties (and possibly a stringent point-system) would enable society to ensure compliance with heavy-duty vehicle speed limits without a great increase in governmental outlays.

B. Capital Investment by Industry

The slower average vehicle speeds which would be the result of this conservation initiative would decrease the amount of freight which could be transported per truck per unit of time. Thus, to continue shipping the same volume of freight per unit time would require the utilization of additional heavy-duty freight trucks or the shifting of part of the current truck freight portion to other modes such as rail or marine (assuming that there is not a great opportunity to decrease the total freight ton-miles by source-to-destiny optimization, which is not likely in the near term). Both the increase in trucks and the mode shifting would require some increase in capital investment by industry. This determination is very difficult to predict, and no attempt will be made at this time to do so, but we would not expect the necessary capital investment to be prohibitive. It must be noted that the extent to which lower speed limits would encourage the shifting of freight transport to rail or marine transport would magnify the fuel savings due to this initiative since both rail and marine freight transport are more fuel efficient. In addition, the increased heavy-duty freight truck utilization would provide more jobs - both for truck drivers and manufacturers.

C. "Cost" per Gallon of Fuel Saved

Since heavy truck usage is a commercial operation, a value must be placed on the extra time necessary to travel at 43 mph rather than the current average speed of 58 mph. Using this value, a "cost" of the fuel saved per gallon can be calculated. Using the following information:

1. 4.7 mpg at 58 mph
2. 6.4 mpg at 43 mph (27 percent fuel savings)
3. A time value of $10 per hour

then at 43 mph, the fuel saved would "cost" about $1.05 per gallon. The time value of $10 per hour was chosen after consideration of the other (non-fuel saving) economic benefits associated with the 43 mph average speed, such as prolonged vehicle and tire lives, lower accident rates, and smaller maintenance and insurance costs. Even if a time value of $20 per hour was assumed and no monetary value was placed on the other benefits of the 43 mph speed, the "cost" per gallon of fuel saved would only be $2.10 per gallon.

Supply

As mentioned above, lower average heavy-duty vehicle speeds would likely require either the utilization of more heavy-duty freight trucks or else a shifting of some percentage of the current truck freight share to other modes such as rail or marine. If the entire freight ton-mile per unit of time differential were to be made up by simply using more freight trucks, then there might very well be a supply problem, particularly under the 30 mph speed limit scenario. But it seems likely that at least some mode shifting would occur. Certainly one of the primary reasons why shippers use trucks instead of rail, despite the fact that it is often more economical to use rail, is because of the ability of trucks to make the delivery considerably faster. The implementation of lower speed limits would narrow the trip time differential which would make rail proportionally more attractive, and which might allow economic considerations to override the smaller trip time differential, thus encouraging some mode shifting. Of course, such mode shifting would require additional rail cars and/or ships or barges, but this seems not to be a major problem. In fact, increased utilization could be a very welcome stimulus to the railroad industry.

Impacts

A. General Economic Impacts

1. Truck Owners

Certainly truck owners would be one of the groups most directly affected by this conservation initiative. In direct economic terms, truck owners would benefit from lower average speeds through lower fuel consumption and lower fuel costs, prolonged vehicle and tire lives, lower accident rates, and smaller maintenance and insurance costs. On the negative side, they would suffer a loss of productivity in terms of ton-miles per truck/driver combination per unit time. It cannot now be predicted exactly how the total economics would work out; however, for the 45 mph speed limit case, for example, a first order effect calculation shows that fuel savings alone will pay the driver/owner over $14.00 per extra hour on the road (Assumes: at 58 mph, truck fuel economy is 4.7 mpg; decreasing speed to 43 mph reduces fuel consumption 27 percent; and fuel costs $1.50 per gallon). However, it is still impossible to predict the reaction of truck owners to a lowering of freight vehicle speed limits. It is certainly true that some truck owners presently operate their vehicles as fast as legally permissible; one conclusion would be that these owners believe that it is in their economic interest to operate at the high vehicle speeds. On the other hand, it is quite possible that while it might be competitively disadvantageous to operate at lower speeds while other trucks operate at 60 mph (in terms of competing for similar shipments), it might very well be more economic for the entire industry to operate at lower speeds (with no differential equity problems). In fact, many large truck fleet owners have concluded that complying with the 55 mph speed limit saves them money overall.15/ It has been owner-operators which have been much more resilient to lower speeds. Again, it would seem that owner-operators would be much more receptive to the idea of lower speeds if all freight trucks were required to conform to them. We believe that strict enforcement is critical to assure that the violator is not rewarded by gaining more of the jobs because of quicker delivery. Also, owner-operators would benefit in the short term as the capacity of the fleet operators would be lessened due to the need for more trucks and drivers and the resultant supply lag. This means that the owner-operator would have an increased business demand placed on them.

The above discussion ignored the question of whether some freight might be shifted from trucks to rail, marine or air transport. To whatever extent that this mode shifting occurs (which would be energy efficient if shifted to rail or marine, energy inefficient if shifted to air), truck owners would probably publicly oppose lower speeds. But the general question of mode shifting must be dealt with elsewhere; suffice to recall that it has been government policy, to a large extent, which has encouraged mode shifting of freight for decades, specifically the shift from rail to less fuel efficient trucks for medium and long-distance freight movements.

In conclusion, we believe there would be opposition from truck owners (especially owner-operators), but that this opposition would be minimized if the lower speed limits were stringently enforced so that trucks willingly complying would not be subject to large trip time differentials compared to trucks exceeding the speed limit.

2. Truck Drivers

Truck drivers will be divided into two groups, those which work for fleet owners (who do not own their own trucks) and owner-operators (who own their own trucks). The former would not be greatly affected by the lower speed limits. As has been pointed out many times, the primary result of lower average speeds would be a decrease in freight ton-miles per truck/driver combination per unit time. If it is assumed that the truck owner makes less profit on his investment (not expected however), then the truck driver may suffer as well. But, as discussed above, it is likely that the cost savings would offset the truck/driver productivity decrease. In fact, if only minimal mode shifting occurred and the same amount of freight ton-miles continued to be transported by trucks, there would be more jobs available for truck drivers. It is likely that the truck driver's unions would support this initiative.

One other impact on truck drivers must be noted. Lower average vehicle speeds would increase the total time necessary for a given round trip. While not a major problem in and of itself, this increase could pose problems for the driver who makes very long round trips and who is already away from home and family for extended periods of time. The increased absence could promote greater stress on the driver and his (her) family. To remedy this problem it might be necessary to redesign the routing and linking of intercity truck shipments.

As drivers, owner-operators would likewise have few problems with slower average speeds. As owners, their possible impacts were discussed in the previous section.

3. Retail Outlets/Consumers

There remains the question of how the lower average speeds would affect the prices of products sold to retail outlets and subsequently purchased by consumers. Again, this question primarily centers on whether the truck owner finds it cheaper or more expensive to ship at the lower speeds, i.e., whether the decreased fuel, maintenance, insurance, and accident costs are less than or greater than the decreased income due to the lower quantity of ton-miles per truck/driver combination per unit time. The information is not now available to make a final determination, but it has already been pointed out that many large fleet owners have concluded that compliance with the 55 mph is to their economic advantage. Thus, we would not expect any significant impact on retail prices.

B. Safety Impact

Heavy trucks are an important parameter with respect to highway safety. Traffic accidents involving heavy trucks (greater than 26,000 pounds) killed an estimated 4,624 people in 1978, a 40 percent increase since 1975.16/ There is an important equity consideration involved in heavy truck/passenger vehicle accidents, as approximately ten times more passenger vehicle occupants die in such accidents than truck drivers, regardless of who is at fault.17/ And the situation will likely worsen in the next decade as passenger vehicles become smaller and lighter while heavy trucks remain the same size or, in some states, get even larger and heavier, and as the freight truck industry continues to grow.

It is now accepted that the imposition of the 55 mph speed limit in January 1974 increased highway safety. The ensuing initial speed reductions (from 65.0 to 57.6 mph average speeds for all vehicles on rural interstate highways) were accompanied by a 16.4 percent drop in total highway fatalities (55,087 in 1973 to 46,049 in 1974).18/ Besides the change in the speed limit, several other factors were responsible for the fewer fatalities, such as an overall reduction in travel, a reduction in average occupancy, the increased use of seat belts, and a shift toward daytime driving.19/

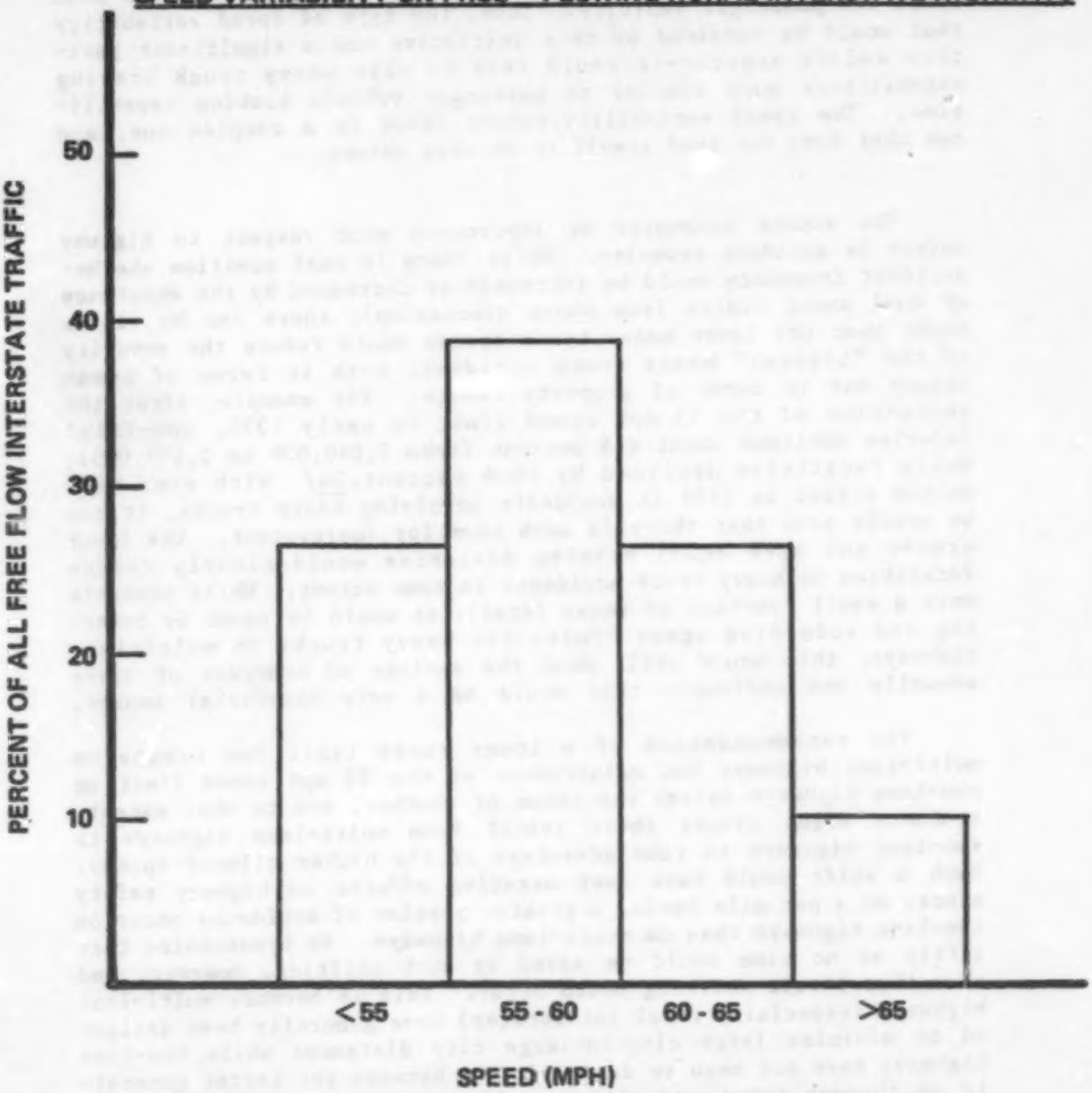
It has been estimated that the lower average vehicle speeds were responsible for 46 to 59 percent of the total reduction in highway fatalities.20/ This initiative varies from the 55 mph speed limit in one important way -- while the latter applied equally to, and slowed down, all vehicles, this initiative would slow down heavy trucks only. Thus, while the fact that trucks would be travelling slower would be advantageous, one must also consider the ramifications of the 10 mph speed differential that would exist between heavy trucks and passenger vehicles. We will examine the two parameters of accident frequency and accident severity.

Several factors affect accident frequency, including both vehicle speed and the speed differential between vehicles on the road. It has not been conclusively determined which of these factors is of primary importance in predicting accident frequency, but it has been hypothesized that the speed differential factor is actually more critical.21/ If indeed the speed differential is more important than vehicle speed in determining heavy truck accident rates, then this initiative could actually increase heavy truck accident rates. But another factor must be considered here. It has been well documented that a majority of all front-to-rear heavy truck/passenger vehicle accidents occur with the truck striking the passenger vehicle from the rear.22/ There is a very logical reason for this -- in-use trucks are not able, or required, to have the same braking capabilities as passenger vehicles. Automobiles travelling 20 mph are currently required to be able to stop within 25 feet while trucks over 10,000 pounds travelling 20 mph need only to stop within 40 feet. And to worsen the problem, surveys have shown that trucks are less likely to meet the braking distance standards than are cars.23/ For safety reasons, all vehicles on the same road should be able to stop within approximately the same distance. But clearly this is not now the case. This initiative, by reducing the speed of heavy trucks relative to passenger vehicles, would reduce the braking distance discrepancy and would surely reduce the most common front-to-rear heavy truck/passenger vehicle accident, which is when the former strikes the latter from the rear. In summary, then, it is not clear whether the speed differential increases or decreases accident frequency. In view of the great concern over the safety ramifications (and traffic congestion discussed below) of a lower truck speed limit on 2-lane highways, it has been concluded that the lower truck speed limit ought to be implemented only on highways where the presence of at least two lanes in each direction provides the opportunity of designating one lane for slower vehicles (e.g., trucks at 30 or 45 mph) and at least one lane for faster vehicles (e.g., passenger vehicles at 55 mph).

The issue of speed variability is an important one. But it must not be forgotten that there is presently significant speed variability on U.S. highways. Figure 1 graphically shows the free-flowing speed variability which exists on rural interstate highways. 26 percent of all free-flowing traffic travels at less than 55 mph, while 10 percent exceeds 65 mph. Thus, there is a 10

FIGURE 1

SPEED VARIABILITY ON FREE – FLOWING RURAL INTERSTATE HIGHWAYS



SOURCE: 1978 HIGHWAY STATISTICS, TABLE VS - 1, p. 49

mph or greater speed differential for a significant percentage of all rural interstate traffic, and few would argue that it is fairly common for 20 mph speed differentials (50 to 70 mph, for example) to exist as well. If there is going to be speed variability, the goal should be to encourage the type of variability that is most conducive to safety. As the discussion above indicated, most heavy truck/passenger vehicle accidents involve the truck striking the passenger vehicle from the rear, partly as a result of the reality that truck braking capabilities are less than those for passenger vehicles. Thus, the type of speed variability that would be required by this initiative has a significant positive safety aspect--it would tend to make heavy truck braking capabilities more similar to passenger vehicle braking capabilities. The speed variability/safety issue is a complex one, and one that does not lend itself to an easy answer.

The second parameter of importance with respect to highway safety is accident severity. While there is real question whether accident frequency would be increased or decreased by the existence of dual speed limits (see above discussion), there can be little doubt that the lower heavy truck speeds would reduce the severity of the "typical" heavy truck accident, both in terms of human injury and in terms of property damage. For example, after the imposition of the 55 mph speed limit in early 1974, non-fatal injuries declined about 6.6 percent (from 2,840,000 to 2,653,000), while fatalities declined by 16.4 percent.24/ With over 4600 people killed in 1978 in accidents involving heavy trucks, it can be easily seen that there is much room for improvement. The lower speeds and more equal braking distances would clearly reduce fatalities in heavy truck accidents to some extent. While probably only a small fraction of these fatalities would be saved by lowering and enforcing speed limits for heavy trucks on multi-lane highways, this would still mean the savings of hundreds of lives annually and obviously this would be a very beneficial impact.

The recommendation of a lower speed limit for trucks on multi-lane highways but maintenance of the 55 mph speed limit on two-lane highways raises the issue of whether, and to what extent, truckers might divert their travel from multi-lane highways to two-lane highways to take advantage of the higher allowed speeds. Such a shift could have very negative effects on highway safety since, on a per mile basis, a greater portion of accidents occur on two-lane highways than on multi-lane highways. We hypothesize that little or no time could be saved by such shifting, however, and thus that little shifting would occur. This is because multi-lane highways (especially rural interstates) have generally been designed to minimize large city-to-large city distances while two-lane highways have not been so designed, and because the latter generally go through towns and cities with the accompanying "delays" of slower speed limits, traffic lights, and stop signs. Thus, we doubt that many truckers would find such shifting to be desirable.

In conclusion, we believe that a lower speed limit for trucks on multi-lane highways, while maintaining the 55 mph speed limit for passenger vehicles, would improve highway safety. The effect of the dual speed limits on accident frequency is not clear -- generally the speed differential between trucks and cars would be considered a negative factor, but this is ameliorated to some degree in that it would only exist on multi-lane highways (which allow for a natural separation of traffic flow) and is counterbalanced by the positive result that the achievable braking distances for trucks and cars would be more equal. But we are convinced that the lower truck speed limit would reduce accident severity, both in terms of human injury and property damage. It is likely that hundreds of lives would be saved annually by enforcing a lower speed limit for heavy trucks on multi-lane highways.

C. Environmental Impact

EPA has performed a fairly extensive analysis of the effect of different steady-state speeds on heavy-duty diesel truck emissions.25/ From an examination of the results from 12 diesel freight trucks, it appears that lower average diesel truck speeds would likely affect hydrocarbon and carbon monoxide emissions very little. But the above study shows that nitrogen oxides and carbon dioxide emissions would decrease, which would be expected due to the lower work-output requirements of the engine. Smoke emissions would also likely decrease. Finally, the noise levels from heavy-duty trucks would be lowered.

D. Mode Shift Impact

As already discussed, it is possible that the strict enforcement of the 55 mph speed limit and/or the lowering of the maximum speed limit to 30 or 45 mph for freight trucks would encourage some shippers to switch from utilizing trucks to utilizing rail or marine or air for their intercity freight shipments. To whatever extent that mode shifting to rail or marine occurs, it would provide an additional fuel conservation benefit as marine and rail are three to five times as energy efficient as trucking for intercity freight shipment.26/ Should part of the current truck freight shift to air transport, however, there would be an energy loss, as air freight transport is about five times more energy intensive than is truck freight transport.27/ Our judgement is that under the strict enforcement of the 55 mph speed limit and under the 45 mph speed limit scenarios, even though little freight shifting is expected, more freight would be shifted to rail and marine transport than to air transport resulting in a net energy gain. Under the 30 mph scenario, there would be increased motivation to shift shipments involving time sensitive commodities to air transport, and it is not clear whether this shift would be greater or less than the shift to marine and rail that would also be expected.

E. Impact on Traffic Congestion

Traffic congestion is very sensitive to changes in speed limits, average speeds, and speed differentials. Since this initiative proposes lowering the speed limit for heavy-duty trucks while not affecting the speed limit for passenger vehicles, there would be an inherent speed differential on the nation's highways. This speed differential could have a significant effect on traffic congestion (and on safety, as discussed above), especially on two-lane highways where there would be no opportunity to separate freight truck flow from passenger vehicle flow. This speed differential might be expected to also pose significant problems on multi-lane urban highways because of the high traffic volumes, except that maximum traffic flows occur between 37 and 45 mph, and thus, as traffic builds the average speed falls.28/ This speed differential should not cause significant problems on multi-lane highways, especially rural interstate highways, since the multiple lanes in each direction would provide a natural separation of flow, i.e., passenger vehicles would generally utilize the left lane(s) while freight trucks would generally utilize the right lane. When truck traffic volumes were low passenger vehicles could also use the right lane. With more strict enforcement of both the 55 mph speed limit for passenger vehicles and a lower speed limit for freight trucks, there would generally be less need for passing as almost all traffic would be travelling within a few miles per hour of their maximum speed limit. Thus, while imposition of a lower freight truck speed limit could cause substantial traffic congestion problems on two-lane highways, we do not think it would significantly affect congestion on multi-lane highways, especially rural interstates. Thus, consideration of congestion problems would favor lower heavy-duty truck speed limits only on multi-lane highways.

F. Impact on Delivery Times

The longer trip times which would be a result of lower average speeds could affect retail outlets and consumers with respect to the availability of time-sensitive commodities such as fresh fruits and vegetables. It might result that certain parts of the country would be somewhat less able to receive some commodities (at least during certain times of the year), or it might encourage time-sensitive commodities to be shipped via air transport, which, as discussed above, is much less energy efficient, and which would increase prices as well. However, with refrigerated trucks and only a 26 percent decrease in travel time (for a 1000 mile trip, less than 4 1/2 hours increased delivery time for the 45 mph scenario), no significant impact is expected here.

Implementation

A. Strict Enforcement of the 55 mph Speed Limit

The most direct way to ensure that state and local law enforcement agencies strictly enforce the current 55 mph speed limit would be for the Federal government to expand and place more importance upon its speed monitoring program and to impose financial sanctions (the loss of highway construction funds) against states which fail to enforce the law. A law should be enforced or repealed. To continue to build political support for such a move, the national consumer information campaign that has begun on the advantages of the 55 mph speed limit should be broadened. This campaign, along with rising fuel prices, will tend to encourage greater compliance with the 55 mph speed limit regardless of enforcement activities, but there is likely to be a substantial percentage of drivers which will not comply until the direct threat of monetary penalty is strengthened. This portion of the driving public has an effect on another portion which would tend to comply if everyone else were, but which tends to exceed the speed limit because "everybody else is doing so." Thus, stronger enforcement activities will not only "coerce" those who really prefer to drive faster, but will also facilitate compliance by those drivers who are willing to drive 55 mph but who want to see everyone "sacrifice" equally, and who get very frustrated by drivers passing them at 60 to 65 mph.

B. Lowering of Heavy Truck Speed Limit to 30 or 45 mph

The 55 mph speed limit became law in all 50 states only after the Emergency Highway Energy Conservation Act of January 1974 threatened states with the loss of Federal highway construction funds if they chose to keep speed limits in excess of 55 mph. Similar Congressional legislation would be required to lower heavy truck speed limits to 30 or 45 mph.

Significant political opposition to such legislation could come from the trucking industry. It is not clear at this time what the reaction would be from the large fleet owners; it would likely depend upon their conclusions as to its economic impact on them. Likewise, it is not clear what the reaction of the Teamsters would be to lower speed limits; however, we believe that once they have evaluated the effects of this initiative (increased driver safety and more jobs), they will support its implementation. Like large fleet owners, the Teamsters generally supported the imposition of the 55 mph speed limit.29/ But it is likely that lower speed limits would cause a tremendous outcry from the independent truckers and owneroperators who have been very vocal against the 55 mph speed limit. A major effort should be made to provide the independent truckers with an objective analysis of the impact of implementing this initiative on them.

The trucking lobby has been very successful in recent years in defeating the passage of legislation that it did not approve of. This may be changing, however, as the Senate recently (April 15, 1980) overwhelmingly passed a trucking bill designed to promote competition, despite opposition from major truckers and the Teamsters. In order to build sufficient support for Congressional legislation to lower the heavy truck speed limit, a considerable education campaign would have to take place. Different approaches would be appropriate for different groups. To truck owners, the general issue of fuel conservation should be emphasized, within a context of calculating the total economic benefit of driving slower (lower accident, insurance, and maintenance costs, prolonged vehicle and tire life, etc.). To truck drivers, the safety benefits should be stressed, along with the more abstract benefit of being able to be a bit more relaxed at lower speeds. To the general public, both the fuel conservation and safety impacts should be emphasized, as part of a coherent conservation campaign.

Although it is still possible that the trucking lobby would mount a public relations campaign against the initiative, this issue could bring about a broad coalition of support. Those groups which support energy conservation and a lesser reliance on imported oil, highway safety, environmental concerns, and a stronger rail freight system would all support lower speed limits for heavy trucks. And if coordinated within a comprehensive conservation program whereby everyone and every group does what it can to save energy, the general public would likely come to the conclusion that the trucking industry, like everyone else, must do whatever it can to lessen our dependence on foreign oil . . . But, what if the truckers say, "Why not make everybody drive at the slower speed then?" First, considering the 45 mph speed limit, fuel savings in dollars per extra hour for cars are less than 1/6 that of heavy-duty trucks - $14.25 for heavy-duty trucks versus $2.37 for cars (Assumes: at 58 mph, truck fuel economy is 4.7 mpg and car fuel economy is 16 mpg; decreasing speed to 43 mph reduces fuel consumption 27 percent for trucks and 15 percent for cars; and fuel costs $1.50 per gallon). Second, there is a high likelihood that passenger shifting from cars to aircraft would occur to negate any fuel savings from the 45 mph speed limit for cars. For example, in a 1978 study conducted by United Technologies Research Center for the Department of Energy, it was concluded that, "the savings resulting from the lower speed limit (from 55 to 50 mph) is nearly eliminated by shifts to air."30/

Recommendation

On the basis of the foregoing analysis, it is recommended that the Federal government take strong action to ensure that the 55 mph speed limit be enforced. This is done most forcefully by withholding highway construction funds from states which do not get in-use compliance. The states should be encouraged to increase enforcement resources and, more importantly, to increase the penalties for drivers which do not obey the speed limit. Just in terms of heavy-duty freight trucks, strict enforcement of the 55 mph speed limit would save 76,000 barrels of oil daily. There would also be accompanying benefits in terms of safety and some forms of pollution. The only negative impact would be slightly longer delivery times for those vehicles which now exceed the speed limit. Clearly, the benefits outweigh the drawbacks in enforcing the 55 mph speed limit.

We have also shown the significant fuel savings which are possible by lowering the speed limit for heavy trucks to 45 and 30 mph. We reject the 30 mph speed limit because the large speed differential that would exist between freight trucks and passenger vehicles (30 mph for trucks, 55 mph for cars) could cause real problems in terms of congestion and, possibly, safety as well.

The lowering of the heavy truck speed limit to 45 mph could cause congestion, and possibly safety, problems on two-lane highways. But we have concluded that the speed differential would be of much less importance on multi-lane highways, where the multiple lanes could actually serve as a natural traffic separator. Additional fuel savings (over those gained from enforcement of the 55 mph speed limit) of 65,000 barrels of oil daily are possible and we believe there would be safety and environmental benefits as well. There might be additional energy savings if some portion of the freight now shipped by truck were switched to rail or marine (though a switch to air for time-sensitive commodities could obviate additional conservation).

Thus, we recommend that Congress pass legislation requiring a 45 mph speed limit for heavy-duty trucks on all multi-lane highways, with a strong provision ensuring the loss of highway construction funds for states refusing to enact and enforce the 45 mph speed limit for heavy-duty trucks. This would result in a total savings of 141,000 barrels of oil per day based on 1977 consumption.

References

1/ Transportation Energy Conservation Data Book Edition 3, D. B. Shonka et al., Oak Ridge National Laboratory - 5493 for DOE, February 1979, pp. 1-18, (hereafter "Data Book").

2/ Alternative Fuels and Intercity Trucking, Prepared by Ryder Program in Transportation, University of Miami for DOE, June 1978, HCP/M3294-01, p. 37, (hereafter "Alternative Fuels . . ."), (Source: Eric Hirst, April 1973).

3/ "Alternative Fuels . . .," p. 84 (Source: Jack Faucett and Associates, July 1976).

4/ "Data Book," pp. 2-13 and 2-15.

5/ "Data Book," p. 1-18 and 3-40.

6/ "Special Speed Monitoring Survey: Trucks and Buses," DOT, NHTSA, March 1979.

7/ The Double-Nickel Challenge Race to the Fuel Pump, DOT, NRD-20, May 1979, Page 4, (hereafter "Double-Nickel Challenge").

8/ Highway Statistics, 1978, DOT, Federal Highway Administration, p. 47.

9/ Fuel Consumption of Tractor-Trailer Trucks as Affected by Speed Limit and Payload Weight, Anthony J. Broderick for DOT, DOT-TSC-OST-75-3, November 1975, pp. 6-12.

10/ "Trucker's Guide to Fuel Savings," Exxon Technigram, D250, April 1, 1974, p. 4 (data from Cummins Engine Company, Inc. Booklet).

11/ Draft of article by the Voluntary Truck and Bus Fuel Economy Program DOT, May 1979.

12/ "Double-Nickel Challenge," p. 30.

13/ Fuel Economy of Heavy-Duty Vehicles, Chester J. France, EPA, Standards Development and Support Branch, HDV-76-01, September 1976, p. 5.

14/ An Engineering Analysis and Comparison of Railroad and Truck Line-Haul Work (Energy) Requirements, Edward K. Morlok, U. of Pennsylvania, March 1976, pp. 36-37.

15/ "Double-Nickel Challenge," p. iii.

16/ "Increased Truck Size and Weight, The Impact on Highways, Safety, and Energy," Central States Resource Center, March 1980, p. 19 (hereafter "Increased Truck Size . . .").

17/ "Increased Truck Size . . .," p. 22.

18/ Fatal and Injury Accident Rates, 1974, U.S. DOT, Federal Highway Administration, pp. 26, 38.

19/ "Assessing the National 55 mph Speed Limit," Charles Clotfelter and John Hahn, Policy Sciences, 1978, p. 290.

20/ National Safety Council, Statistics Division, "Factors Contributing to the Reduction of Motor Vehicle Traffic Fatalities," October, 1974 and March, 1975, Chicago, Illinois.

21/ Purdue University/Indiana State Highway Commission Joint Highway Research Project, "Characteristics of Heavy Truck Accidents," A.E.S. Rodwan, June, 1976, pp. 68-69.

22/ "The 55 MPH Limits and Front-to-Rear Collisions Involving Autos and Large Trucks," Loren A. Zaremba and Marvin J. Ginsburg, Accident Analysis and Prevention, Volume 9, pp. 303-314, 1977.

23/ "Increased Truck-Size . . .," p. 23.

24/ Fatal and Injury Accident Rates, 1974, DOT, Federal Highway Administration, pp. 26, 38.

25/ Study of Emissions from Heavy-Duty Vehicles, EPA-460/3-76-012, May, 1976.

26/ "Data Book," p. 2-27.

27/ "Data Book," p. 2-27.

28/ Leiferman, Michael, "Driving Cycles for Sulfate Measurement", Report of the U.S. Environmental Protection Agency, April 15, 1975.

29/ "Can We Force 55," Fleet Owner, April, 1978, p. 80.

30/ Model Shifts in Short-Haul Passenger Travel and the Consequent Energy Impacts, Report of the United Technologies Research Center for the Department of Energy, March, 1978.

Increased Speed Limits for More Fuel Efficient Cars on Interstate Highways

Summary

This proposal suggests an optional qualification procedure by which fuel efficient automobiles can be approved for a 70 mile per hour daytime speed limit on rural Interstate highways. Such a program would provide an attractive non-monetary incentive for purchasing fuel efficient vehicles. A fuel savings of about 23,000 barrels of gasoline per day is projected within one year of implementation increasing to about 140,000 barrels of gasoline per day after 7 years of implementation. Safety related penalties of such a program are projected to be small, although available data are not entirely clear. Congressional action would be necessary to implement this initiative.

Background

In February of 1974, the mandatory 55 mile per hour speed limit was imposed by the Federal government. This speed limit was a direct result of the OPEC oil embargo in late 1973. The speed limit which covered all trucks, buses and passenger cars was supposedly imposed only for the savings in fuel economy resulting from lower speeds. The new "double nickel" standard was equally, and some would say unfairly, enforced on both "gas guzzlers" and "fuel efficient" automobiles. Thus, a fuel efficient vehicle owner was required to drive slower, partially because of the inefficient vehicles. This new speed limit was implemented to quickly reduce domestic fuel consumption.

A large reduction in automobile related accidents and fatalities was noted after the implementation of the 55 mph speed limit. This reduction was accredited to the new speed limit. In the past few years it is the reduced accident claims which have provided the emphasis for retaining and enforcing the 55 mph speed limit, and not so much the fuel economy benefits.

Fuel Conservation Potential

This initiative would result in fuel savings in two areas. First, the proposed 70 mph speed limit would create a positive incentive for purchasers of automobiles to select fuel efficient automobiles. This shift in buyer preference would ease the burden of automobile manufacturers to meet Corporate Average Fuel Economy (CAFE) standards. Therefore, the ability of manufacturers to reach higher CAFE levels after 1985 would be enhanced by this initiative. While exact numbers cannot be estimated, the positive impact of implementation of this initiative on future CAFE standards should be significant.

The second area of fuel conservation is where purchasers of "70 mph vehicles" operate their qualified vehicle on non-Interstate roads. If 10 percent of the vehicles purchased per year are qualified to the 70 mph standard, the initiative would result in 23,300 barrels gasoline/day savings for the first year, increasing yearly to an equilibrium of about 140,000 barrels/day - based on the following calculations:

1. New vehicle registrations (1978) = 10,946,000 1/
2. 10 percent of these vehicles = 1,094,610 vehicles assumed qualified to 70 mph standard.
3. A vehicle qualified at 70 mph would save 15 percent or more2/ by going 55 mph, over one which was qualified at the same mpg rating using the current EPA HFET cycle (average speed of 48 mph).
4. 29.7 percent of all U.S. travel is on non-Interstate, main rural roads where 55 mph is, and would remain, the speed limit.
5. If a 15 percent fuel economy saving was noted on 10 percent of vehicles during 29.7 percent of the vehicle miles traveled, the cumulative fleet savings would be .445 percent.
6. There are 5.233 million barrels of gasoline consumed by passenger cars in the U.S. every day.
7. The fuel consumption savings of .445 percent would result in a 23,288 barrel per day fuel economy saving.
8. This figure is a cumulative figure. After two years of implementation the vehicles qualified to the 70 mph standard would yield a fuel economy benefit of 0.89 percent. After 3 years a savings of 1.34 percent would be realized.
9. Assuming an average age of 6.3 years for the vehicle fleet a total sum of 2.67 percent or 139,700 barrels of gasoline per day could be achieved by this initiative.

The sum of the improved CAFE standards and the non-Interstate fuel economy benefits make this a significant fuel conservation initiative. Additional fuel economy benefits would be realized if owners of qualified 70 mph vehicles drove on Interstates at below 70 mph speeds.

Cost to Implement

The actual cost per vehicle to implement this initiative would be negligible. The cost of the qualifications procedure would be the same as using the present EPA Highway Fuel Economy Test (HFET), so no additional cost would be incurred.

State and local government costs would be incurred by:

1. Installing proper 70 mph speed limit signs.

2. Increased speed limit enforcement to ensure drivers are impressed with the benefit of driving a "fuel efficient" vehicle.

3. Registration and special license plates for "fuel efficient" vehicles.

The cost of these three items would be quite low on an overall analysis.

Supply (of the new technology)

The requirements to set up the optional 70 mph qualifications and to implement them would not necessitate any new technology. The EPA would have to develop an appropriate 70 mph HFET. Similar test requirements have been handled in the past so the equipment and expertise is readily available.

The requirements for the auto manufacturer would be to run the 70 mph HFET instead of the 55 mph HFET. The equipment and expertise is again readily available.

The state and local governments would not need to utilize any new equipment or technology to produce special license plates, systemize the special registration of fuel efficient vehicles and increase enforcement of the Interstate speed limits.

Impacts

A. Economic

The only economic impact would be the expected higher price for "Fuel Efficient" vehicles to the ultimate purchaser. The increased cost is not expected to be significant, and in any case would be a voluntary consumer choice.

B. Safety

1. Dual Speed Limit Impact

Critics of this proposal will quickly point to the safety problems of two speed limits: that 55 mph for "gas guzzlers" and 70 mph for "fuel efficient" vehicles will be a safety problem. Prior to 1973 all highways and casual roads operated satisfactorily with dual speed limits for trucks, U.S. passenger cars, daylight vs. night driving and trailers vs. non-trailers. The majority of "two speed" safety related problems were encountered in high-speed two-lane roads, not Interstate roads where passing of slower vehicles is simplified by the passing lane. This initiative would implement the dual speed limits only on Interstate roads for only daytime driving.

2. Overall Safety Aspects of Increased Speed Limit on Interstate Highways.

Many of the safety claims accredited to the reduced speed limit were due to other circumstances. J. Carpenter in "Traffic Fatalities and the Energy Crisis"3/ showed a 24.4 percent reduction in nationwide fatalities between equivalent time periods in 1973 and 1974. Other circumstances involved in the 24.4 percent reduction are:

1.	Gross reduction in traffic volume	6.2%
2.	Transfer from night to day driving	6.0%
3.	Historical drop in accident rates	3.6%
4.	Shift from weekend to weekday driving	1.3%
5.	Shift from rural to urban driving	.2%
		17.3%
6.	Shift to pedacycle & motorcycle	(-) 1.2%
		16.1%

Therefore an 8.3 percent (24.4 - 16.1) reduction can clearly be accredited to the 55 mph reduced speed limit. The National Safety Council's statistics attributed 11 of the 24 percent decrease to reduction in speeds.4/ Many other articles claiming 20-30 percent accident reduction (see references 5/6/7/ and 8/) fail to distinguish the 55 mph speed limit effect from the mitigating circumstances. MVMA figures for 1973 and 1974 show a 15.33 percent reduction in fatalities per mile. Correspondingly, there was a 16.74 percent (16.4 percent according to Federal Highway Administration)9/ reduction in traveled Interstate highway fatalities/ mile.1/ It is important to note that the next year, 1975, showed a 9.64 percent reduction in interstate fatalities/mile.1/ This shows that the 16.74 percent figure is not solely due to the 55 mph speed limit which was in effect for most of 1974 and all of 1975.

The MVMA figures also show that the percentage of fatalities on Interstates was 10.6 percent in 1973 and 10.48 percent in 1974. Therefore, the reduced speed limit safety impact was across all means of motor vehicle travel, not just Interstate.

Because:

1. The Interstate accounts for only 10 percent of the fatal accidents on a per-mile basis;

2. Other considerations leave the direct impact of the 55 mph speed at about an 8 to 11 percent reduction in fatalities;

3. Only 10 percent of the vehicles are projected to be qualified in the first year;

it is projected that the implementation of this initiative would result in less than .2 percent increase the first year in total fatalities and less than a .5 percent after 3 years of implementation. In addition. limiting the 70 mph speed limit to daylight driving only should further reduce this impact.

Many other methods of Interstate safety improvement could be implemented to more than make up the possible .2 to .5 percent penalty incurred by this idea. Elimination of "booby traps", better lighting, impact barriers, and increased enforcement are a few examples.

Owners of fuel efficient autos would, of course, have the option of going at an Interstate speed between 45 and 70 mph. Therefore, the safety aspect becomes more a matter of consumer choice, not a federally imposed decision.

Implementation

This proposal suggests that the manufacturers of new motor vehicles be given the option of "certifying" candidate EPA fuel economy vehicles to a 70 mph Highway Fuel Economy Test (70 HFET) in place of EPA's current HFET which averages 48 mph. Those vehicles which achieved the Corporate Average Fuel Economy (CAFE) standard, plus 25 percent (in 1985, a standard of almost 35 mpg rather than 27.5 mpg), and which meet the other criteria of this initiative could be sold as "70 mph" vehicles.

Manufacturers who elected to exercise this option would be required to use the 70 HFET figure in their 55/45 CAFE calculations.

The EPA would be required to design a 70 HFET which would represent normal 70 mph, Interstate driving. The testing technology and requirements would be the same as used on the present 48 mph HFET.

State and local government agencies would need to implement proper enforcement and registration proceedings. Because similar regulations and enforcement activities are now in effect, these would be low cost and low training requirements. Special license plates would be needed for "qualified" vehicles. A sharply colored (for example: bright phosphorescent orange or red) license plate issued to vehicles with a specialized Vehicle Identification Number (VIN) number would be an acceptable procedure.

One potential problem would be the groups of consumers who presently own "fuel efficient vehicles". These owners might be irritated by being regulated to a 55 mph speed limit, while owners of new fuel efficient vehicles can go 70 mph. To offset this problem, EPA could develop a "Factor Certification" based on EPA Fuel Economy figures for previously tested models and publish a qualified list. Another method to minimize any such adverse reaction would be to provide a one to two year advance notice before implementation, as current vehicle owners (both of fuel efficient and non-fuel efficient vehicles) could then decide to wait on the purchase of a new car until the 70 mph vehicles were qualified. The owner of a recently purchased non-qualified fuel efficient car could not therefore claim he was a victim of circumstances. However, allowing too much advance notice could result in reduced sales due to consumers waiting for the 70 mph vehicles. It is likely, though, that the availability of such an option even applying only to new cars, is desirous enough to such people that any resistance would probably be minimal for fear of jeopardizing the basic option.

Other implementation considerations are listed below:

1. Consumer Information - Information of this procedure will probably be communicated by those manufacturers selling "70 mph" vehicles much as the "EPA fuel economy figures" are now advertised.
2. Economic Incentive - The incentive for the manufacturers is to provide a vehicle which the public will want to purchase. The economic incentive for the motor vehicle manufacturer then is to qualify and produce "70 mph" vehicles.
3. Regulatory Influence - No impact is expected as the proposed procedure merely substitutes for existing regulations.
4. R&D - No Research and Development is required for the actual procedure. The proposal should encourage R&D aimed at producing fuel efficient automobiles.

Recommendation

It is recommended that Congress amend the Energy Policy and Conservation Act to require the implementation of a provision granting manufacturers of 1985 and later model year passenger cars an option to certify fuel efficient passenger cars to a 70 mph Highway Fuel Economy Test, in place of the current 48 mph Highway Fuel Economy Test. To certify, those vehicles would be required to achieve the numerical value of 1.25 times the applicable Corporate Average Fuel Economy Standard.

It is further recommended that the 70 mph speed limit be restricted to rural Interstate highways and only allowed during daylight hours, and that 70 mph certification be provided only for new vehicles.

References

1/ MVMA Motor Vehicle Facts and Figures 1979, 1978, 1977, 1976, 1975.

2/ U. S. Environmental Protection Agency, "Passenger Car Fuel Economy: EPA and Road", April, 1980.

3/ J. Carpenter, "Traffic Fatalities and the Energy Crises", Four Month Analysis; January-April 1974, General Motors Corporation, Report No. A3176. November 20, 1974.

4/ National Safety Council Statistics Division, "Factors Contributing to the Reduction of Motor Vehicle Traffic Fatalities", October 1974 and March 1975.

5/ N. Enustan, D. Hornbeck, S. Lingeman, A. Yang, "Safety Aspects of the 55 mph Speed Limit", Michigan Department of State Highway and Transportation; Report No. TSD-295-74.

6/ J. O'Day, D. Minahan, D. Golomg, "The Effects of the Energy Crisis and 55 mph Speed Limit in Michigan", Office of Highway Safety Planning Report No. UM-HSRI-SA-75-9.

7/ Bradock, Dunn, and McDonald, Inc., "Impact Considerations of the National 55 mph Speed Limit", Report No. B DM/W-74-064-TR.

8/ "55 MPH Fact Book", Department of Transportation, Report No. DOT-HS-802-140.

9/ U.S. Department of Transportation, Federal Highway Administration, "Fatal and Injury Accident Rates", 1974, p. 26.

Low-Energy Dissipation Tires for Automobiles and Light Trucks

Summary

If all original and replacement tires for passenger cars and personal light-duty trucks were of the current technology low-energy dissipation type, a fuel savings of 100,000 barrels per day could be achieved by the end of 1981, with savings increasing to 400,000 barrels per day by the end of 1984. If the advanced-technology tires now being developed become commercially available by 1983 and are then used extensively, an additional 200,000 to 400,000 barrels per day of fuel could be saved by the end of 1986.

The extensive use of low energy dissipation tires would have minimal adverse effects on the general society. Any additional tire costs incurred by the average consumer would be offset by the increased tire life and/or the resulting savings in vehicle fuel. Only individual tire manufacturers whose current product line consists of predominantly high energy dissipation tires might be adversely affected. No supply problems are anticipated.

The "cost" of the fuel saved by implementation of this initiative is about 18 cents per gallon.

It is recommended that this initiative be implemented through a voluntary tire labeling program supported by an aggressive public information program. If the voluntary labeling program is not effective in realizing the energy conservation potential of this initiative, Congress should then require mandatory labeling in conjunction with minimum Corporate Average Tire standards.

Background

Tires have a very significant effect on the fuel economy of a vehicle. Tires affect the fuel economy of a vehicle by their effect on the force, and hence the work, required from the engine to propel the vehicle.

Figure 1 shows typical force versus speed requirements for a vehicle.1/ This figure indicates that the tire energy dissipation is the major engine power requirement below approximately 40 mph. Because a significant portion of all U.S. driving occurs at speeds below 40 mph, and most of the urban driving is in this speed range, the tire has a very significant effect on the fuel economy of a vehicle.

The above illustrative analysis only considered steady-speed operation of the vehicle; under more typical, cyclical, vehicle-use conditions the inertia effects of the vehicle somewhat diminish the tire effects.

However, the fuel economy effects of tires have been demonstrated using the EPA emissions and fuel economy driving cycles

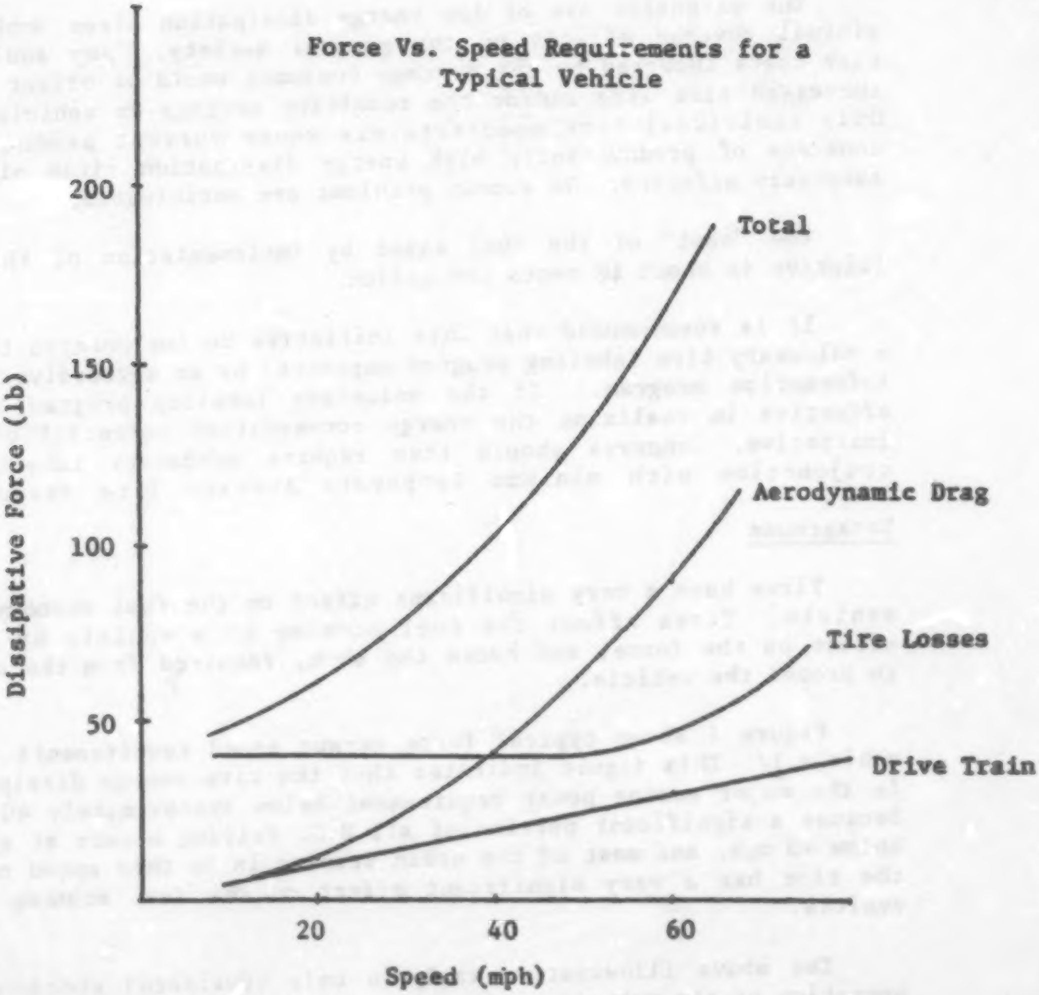

Force Vs. Speed Requirements for a Typical Vehicle
Dissipative Force (lb)
200
150
100
50
Total
Aerodynamic Drag
Tire Losses
Drive Train
20
40
60
Speed (mph)

FIGURE 1

which are transient cycles representative of typical urban and highway vehicle use.2/ Consequently, the fuel economy effects of vehicle tires over these cycles are known and can be used to predict the fuel economy effects of tires in consumer service. These predictions have demonstrated the potential for significant reduction in U.S. annual fuel consumption, if fuel efficient tires were consistently used.3/

Fuel Conservation Potential

At the present time it is widely recognized that, on the average, radial ply tires provide better vehicle fuel economy than bias ply (diagonal) or bias belted tires.4/ Less widely recognized, but well known is the significant variations among tires of the same generic type.5/,6/

These variations between tire type and among tires of the same generic type provides the basis for several scenarios for reducing vehicular fuel consumption. The first scenario represented is to consider the fuel conservation potential if all non-radial tires were converted to radials, the second scenario considers the potential if all tires were converted to the most fuel efficient radial tires currently available, and the final scenario considers the fuel conservation potential of advanced technology radial tires which may be shortly available.

A. Fuel Conservation Potential From the Consistent Use of Average Radial Tires

EPA has empirically investigated the fuel economy effects of radial versus non-radial tires over the EPA driving cycles and has concluded that radial tires provide significant fuel economy improvements in transient vehicular operation typical of average consumer use. Therefore, if vehicles consistently used currently available, average radial tires, the U.S. annual fuel consumption would be reduced.

Currently, about 70 percent of the new passenger car and light trucks sold are equipped with radial tires; however, only about 40 percent of the tires sold for replacement are radials.7/ These data indicate that there is some consumer transition from "original equipment" radial tires to non-radial replacement tires. Reasonable life expectancies for tires are about 33,000 miles for radials, 25,000 miles for bias-belted, and 18,000 miles for bias-ply tires. Therefore, the vehicle which is always equipped with radial tires will require approximately three sets of tires, the "original equipment" set and two replacement sets to reach a reasonable vehicle life expectancy of 100,000 miles. The vehicle which is always equipped with non-radial tires will require the "original equipment" set and approximately four replacement sets to reach its 100,000-mile distance. If, after the "original equipment" radials are worn, the consumer chooses to replace these tires with non-radials, approximately three sets of replacement tires will be required to complete the life expectancy of the vehicle. Using the above replacement assumptions, the anticipated percentage of aftermarket sales which are radial tires will match the observed percentage of sales if approximately 15 percent of the "original equipment" radials are replaced with non-radial aftermarket tires.

Using the tire sales data, the tire life expectancies, and the estimated 15 percent aftermarket transitions from radial to non-radial, it can be calculated that approximately 60 percent of the U.S. mileage is being driven on radial tires. This analysis is presented in greater detail in attachment 1.

EPA investigators have demonstrated that on the average, radial tires improve vehicle fuel economy by 5 percent.2/,6/ This result is consistent with other reported data obtained under similar test conditions.4/,5/ If the 40 percent of the annual U.S. mileage which is now driven on non-radial tires were driven on radials the fuel efficiency of these vehicles would be improved by 5 percent. The total U.S. aggregate fuel consumption would therefore be reduced by approximately 2 percent. This would represent a fuel conservation of about 130,000 barrels per day.

B. Fuel Conservation Potential if Optimum Currently Available Tires Were Consistently Used

Recently, tires with reduced energy dissipation characteristics have been developed.5/,8/,9/ These tires are being introduced for the first time on the 1980 General Motors "X" cars.5/,9/ These new-technology tires show a fuel economy improvement over current-technology radials of 3 to 4 percent.5/ Therefore, if these new-technology tires were consistently used on all passenger cars and light trucks, the fuel economy improvement for the vehicle fleet would be the 2 percent increment in going from non-radials to radials plus the 3 to 4 percent increment in going from current-technology radials to the new-technology radials. This represents a potential fuel conservation of 380,000 barrels per day. These improved fuel economies would be realized over approximately a four-year phase-in period. If the program were to start in 1980, it is projected that 130,000 barrels per day of gasoline could be saved by the end of 1981, 224,000 barrels per day by the end of 1982, and 380,000 barrels per day by the end of 1984. The calculation presenting the assumed transition is given in Table 1.

C. Fuel Conservation Potential if Advanced Technology Radial Tires are Consistently Used

Advanced-technology tires still under development may have the potential for achieving an additional 5 or more percent fuel economy improvement over the optimum tires currently available.5/ Assuming this advanced technology can be introduced by 1983 and assuming that a 6 percent fuel economy benefit is realized, by the

Table 1

Light-Duty Vehicle Fuel Conservation Potential Barrels Per Day

Year	Transition to Radials (2 Percent)	Transition to Currently Available Fuel Efficient Tires (4 Percent)	Transition to Advanced Technology Efficient Tires (6 Percent)	Total
1980	32,000			32,000
1981	64,000	64,000		128,000
1982	96,000	128,000		224,000
1983	128,000	192,000	96,000	416,000
1984	128,000	256,000	192,000	576,000
1985	128,000	256,000	288,000	672,000
1986	128,000	256,000	384,000	768,000

Based on a current estimated consumption of 6.4×10^6 bbl/day.

Transition to radials could logically occur in less than 4 years because of the reduced life expectancy of non-radial tires, however, little effect will probably be seen in 1980.

The above fuel conservation potentials are computed assuming a linear transition over 4 years, the maximum typical tire life expectancy. However, since the tires on the most heavily-used vehicles would tend to be replaced sooner than those on lightly-used vehicles it is possible that the fuel conservation effects could initially occur more rapidly.

Light-duty vehicles refers to passenger automobiles and light trucks.

end of 1986 an additional 380,000 barrels per day of gasoline could be saved by ensuring that these advanced technology tires were used as replacement tires.

Cost to Implement

The cost to the government to ensure that the replacement tires sold in the U.S. exhibited minimum rolling resistance would be very small. The cost to the consumer would be a net savings because of the reduction in the vehicle fuel consumed.

A. Cost to the Consumer

The cost to the consumer will vary with implementation option, but it is generally expected to be a net savings because of the reduced vehicular fuel consumption. EPA investigated the cost of tires versus measured rolling resistance and while low rolling resistance tires are generally radials and tend to be more expensive, there is currently very poor correlation between rolling resistance and tire cost.10/ If consumers were simply provided with rolling resistance information it would be possible to select relatively low rolling resistance tires at relatively low cost. Even if the consumer elected to choose the best currently available radial tire over the lowest cost non-radial tires a net savings of $180 would be incurred over the life of the low rolling resistance radial. The calculation supporting this result is given in Table 2.

It should be noted that if in the example, the vehicle were operated for any distance exceeding the life expectancy of one set of the non-radial tires, the increased life expectancy of the radial tires nearly offsets their initial higher cost, leaving nearly the total fuel conservation as a cost savings. Even if the cost of vehicle operation is only computed for 18,000 miles and the entire cost of the most fuel efficient tires is charged to the operation, the cost of the conserved fuel is still nearly sufficient to offset the initial higher cost of the radial tires.

B. Government Costs

The governmental costs will depend somewhat on the implementation option chosen, however, for any implementation option, the major cost would be the administrative burden of designating some testing laboratory to act as the "official" test site for correlation and comparison purposes and to verify, if necessary, the tire energy dissipation claims made by tire manufacturers. It is projected that the Federal government implementation effort could be accomplished with an equivalent of 20 or fewer positions.

C. Cost to Tire Manufacturers

The cost to tire manufacturers would strongly depend on the implementation options and is further discussed in that section. However, with any of the implementation options, tire rolling resistance testing would be required. The major tire manufacturers are already conducting such tests as part of their programs to develop and sell tires to the automobile manufacturers. Therefore for many tire manufacturers little additional test burden would be expected and therefore little cost would be incurred.

In the case of the smaller independent manufacturers, some test costs would be incurred unless the implementation option was a voluntary program which provided some "default" tire grade option. Even if the small manufacturer were required to conduct tire rolling resistance tests the costs are estimated to be small. Several independent test laboratories have indicated willingness to conduct rolling resistance tests for a cost of about $250 per tire. Even if a manufacturer required 100 tests of each tire line, implementation of the program would only incur a testing cost of approximately $25,000.

D. Cost of Fuel Saved

Using the conservative assumptions contained in Table 2, the "cost" of the fuel saved is about 18 cents per gallon.

Supply

The difficulty of supply depends on the implementation scenario and the desired rate of implementation. Scenarios A and B only require a greater shift of production from non-radials to currently available radial technology. In these instances in particular there should be no supply problems.

In 1973 and 1974 there was a rapid increase in the U.S. production of radial tires, from very few in 1973 to almost 70 million in 1975. If all original equipment tires and replacement tires were now radials, this would require an increase of between 50 to 80 million units of radial tires. This is very nearly equal to the increase in supply which occurred in the 1973 to 1975 time period. If the transition to consistent use of radial tires were to occur more slowly with the sales of non-radials simply reduced each year, then the major initial demand would be reduced by approximately one-half. Under these conditions the increase in demand of 25 to 40 million radial tires would be stable and this would greatly reduce the impact on the industry. The past performance of the tire industry indicates that the industry should be able to respond to such an increase in radial tire demand.

Even in the case of the proposed advanced technology tire for the mid-1980's, supply problems are not foreseen since it is predicted that the advancements will come from changes in rubber compounding, thread depth and inflation pressures and that these tires will not be fundamentally different than the radials which are now in common use.

Table 2

Fuel and Tire Cost to Operate a Vehicle 36,000 Miles

	Lowest Cost Non-Radials	Most Fuel Efficent Current Radials
Tire cost	$ 240 (2 sets)	$ 272 (1 set)
Fuel	2,400	2,184
	$2,640	$2,456

Net savings with the radial tires:

$$
\begin{array}{r}
\$2640 \\
\underline{-2456} \\
\$\ 184
\end{array}
$$

Vehicle fuel consumption of 18 mpg assumed when vehicle was equipped with non-radial tires.

Vehicle fuel consumption assumed to decrease 9 percent when equipped with the most fuel efficient current radial tires.

Gasoline cost assumed constant at $1.20/gal.

Impacts

Some impact on consumers and on the tire industry will occur from any effective tire program for fuel conservation.

A. Consumer Impact

The consumer impact will be a function of the conservation scenario.

In the case of scenario A, the transition to only radial tires, there will be very little aggregate consumer impact. As discussed in the cost section, the total net effect will be a cost savings because of the fuel efficiency and longer life of the radial tire. However, at the time of initial purchase the radial tire generally is more expensive and therefore more economically painful to acquire.

For those individuals where the initial purchase price of new radial tires is a significant economic burden, used radial tires or retreaded radial tires might provide a low cost fuel efficient option. For example, 12 percent of the retreaded tires sold in 1979 were radials.7/ However, consideration should be given to the safety of retreaded radials before encouraging this approach.

In the case where an individual only intended to operate a vehicle a relatively short total distance, less than approximately 20,000 miles, the radial tire will be more expensive at current gasoline prices. Subsequent owners of the vehicle would however, continue to obtain value from the radial tires. If the intent was to scrap the vehicle in less than 20,000 miles, the previous possible option of used radial tires would be an attractive cost and fuel efficient choice.

Radial tires are generally credited with improved safety characteristics. Particularly the lack of constriction of the tread in the tire-road contact patch generally allows better wet traction characteristics for radial tires.12/ In addition, radial tires are often considered as the preferred tire from a vehicle handling stand point.13/ The complete transition to radial tires, scenario A, should result in reduction in vehicle fuel consumption, subsequent reduction in total vehicle operating costs and improvements in vehicle safety.

In the case of scenario B, the transition to the best currently available radial tires, no additional significant impacts beyond those previously discussed for the transition to radials are envisioned. Since these tires do not appear to be priced significantly higher than other radial tires, they may be particularly cost effective for the consumer.

Considering the final scenario, transition to "advanced technology" radial tires, it is possible that some degradation in tire wear and tire traction may result, as compared to current "best" radials.14/,15/ There is, however, no evidence yet that a reduction in traction will necessarily occur when these tires are produced. Also, even if some reduction in traction does occur the characteristics of these fuel efficient radial tires may still be equivalent or superior compared to the characteristics of non-radial tires since current radials generally have wear and traction characteristics superior to non-radials.16/

While any reduction in traction should be carefully evaluated, it does not appear that low rolling resistance tires will impose a significant safety impact. Also, since tire traction is considered in the current DOT tire grading programs, the pressures to limit any potential decrease in tire traction performance already exist.17/

The possibility of decreased tire life is primarily a psychological impact. Tire wear is apparently an important tire parameter for the consumer, and the only tire performance parameter which the consumer can directly measure. Primarily for this reason, tire manufacturers will resist degradation in tire wear characteristics to avoid an adverse reputation for their product. For radial tires especially, there does not seem to be a necessary trade-off of tire wear characteristics for reduced rolling resistance.

B. Environmental Impact

Any approach which calls for conserving fuel by reducing the energy required to operate the vehicle can be expected to have a positive effect in reducing vehicle exhaust emissions.18/ In general, the effect on the NOx exhaust emissions will be the most significant. It would be expected that if a 5 to 10 percent reduction in fuel conservation is obtained this would be accompanied by a reduction of 10 to 30 percent in the NOx emissions, for example.

C. Industry Impacts

Scenario A, which is the essential transition to radials will cause the greatest impact on the tire industry. The necessary increase in the supply of radials will be of the same order as the increase in supply of radials in the early 1970's but will not be as severe an impact as the 1970's transition since the industry now has a large manufacturing capacity for radial tires.

The impact which will be felt is the loss of sales of non-radial tires. This may not be a significant impact on the aggregate industry since the radial tire is more expensive to produce and generally is sold with a higher profit margin. The radial tire is also more labor intensive to produce even though a smaller number of tires will need to be produced. The total labor required will not be affected to as great an extent as might be expected from the reduced number of tires required.

The one element of the tire industry which may be severely affected is that small segment of the tire industry which is not currently producing radial tires. Many of those companies or those manufacturing facilities which are now producing only non-radial tires would require transition to radial tire production or would be forced to concentrate on tire markets other than for automobiles and trucks. One smaller tire manufacturer has indicated that this could have a significant negative effect on its corporation because of the capital investment required to convert to radial production.19/

In regard to the transition to optimum radial tires, little differential impact within the tire industry would be expected. Any manufacturer currently producing radial tires should be able to produce tires equivalent to the optimum tires currently available. In fact, it is expected that all the major tire manufacturers will be supplying these tires for production vehicles beginning in the 1980 model year.

Implementation Options

In order for low rolling resistance tires to be encouraged or required, there must be a standardized, reasonably-accurate method (test procedure) to predict the rolling resistance of a given tire type. EPA began work over two years ago in coordination with the automobile and tire manufacturing industries to develop an acceptable rolling resistance measurement procedure. The coordination has been achieved through the Society of Automotive Engineers (SAE), and has resulted in acceptable rolling resistance test procedures.20/,21/

There are four basic options available to increase the use of fuel-efficient tires as replacement tires. These are:

1. Public Information Campaign

A public information campaign could be conducted by publicizing tire test results from government or contractor laboratories. Current EPA contracts could be used to provide data for initiation of such a program.

This approach has the advantage that results could be published in 1980. The disadvantage is that the burden of identifying the tire in the sales room which corresponds to the published results of the test tire rests with the consumer. If the tire industry so desired it could easily defeat this type of information program by frequently changing tire model or brand names and descriptions. Also this approach might be misleading in the case of major brand name retails such as Sears, Wards, etc. who probably obtain tires from diverse manufacturers.

2. Tire Labeling

A more positive approach would be for tire manufacturers to test representative tires from each of their basic tire lines to establish the rolling resistance characteristics of the particular tire design. This rolling resistance information would then be required to be affixed to each tire in the form of a label indicating the relative fuel efficiency of the particular tire type. This concept could, for example, group tires into three or four different rolling resistance classes or grades (i.e., Grade A, B, C, and D). The consumer would know that a Fuel Economy Grade "A" tire had the best fuel efficiency characteristics and could use this factor in his consideration of which tire type to purchase. The relative fuel savings of one grade as compared to another could be made available through the tire retailers or independently by the Federal government, much as the automobile fuel economy Mileage Guide is now made available by the Department of Energy and the Environmental Protection Agency.

Any public information-labeling program would result in an increased use of low rolling resistance tires. However, there would still be an incentive on behalf of the consumer to purchase high energy dissipation non-radial tires because of their lower cost. In addition, there might also remain an incentive for the tire retailers to sell the less expensive bias and bias-belted tires since such tires wear out more quickly and are conducive to greater tire sales volumes.

3. Energy Inefficiency Tax

On the basis of rolling resistance tests conducted by the tire manufacturers and/or the Federal government, the tires could be taxed on the basis of their relative inefficiency. Such a tax could be structured so as to raise the price of the fuel inefficient tires to be as high as the price of the fuel efficient tires. This would likely result in the consumer purchasing the more fuel-efficient tire since the fuel-inefficient tire would no longer have an initial cost advantage.

The energy inefficiency tax could be structured to be in combination, or as a replacement of the present excise tax. The current excise tax effectively taxes the petroleum used in the construction of the tire by taxing the quantity of rubber in the tire. The more appropriate tax would be one directed toward taxing the total petroleum consumption associated with the tire. That is, both the petroleum used in the manufacture of the tire and "wasted" during subsequent use on an average vehicle would be taxed.

The energy inefficiency tax could be structured so that the current excise tax would be waived on all fuel efficient tires, while fuel inefficient tires could be taxed at several times the rate of the present excise tax. Few consumers would wish to pay an extensive tax for the "privilege" of purchasing fuel inefficient tires. Consequently this approach would provide an inherent incentive for the tire manufacturers to develop more fuel-efficient tires.

4. Energy Efficiency Standard

Each tire manufacturer could be required to produce tires which; a) are all required to meet a minimum rolling resistance standard; or b) on a corporate average basis would meet a specified rolling resistance value. With either of these approaches, there would be full assurance that the full potential energy savings available through the use of low rolling resistance tires in the replacement tire market would be achieved.

Recommendations

The first recommendation is to proceed with a tire initiative as quickly as possible because of the significant conservation potential of tires.

Programs which may be accomplished under existing authority are likely to be effective much sooner than any programs which require legislative action and subsequent rulemaking proceedings. Therefore it is recommended that implementation option 1, the public information program, and implementation option 2, a voluntary tire labeling program, be pursued. EPA has, in fact, recently committed to implement this approach.22/

In the event of the need for a mandatory program, the choice among the latter three implementation options is primarily a choice of policy preference. Since any of these options probably require legislative action, the final policy choice rests with Congress. Any one of these three basic options could be implemented in the near-term. The cost to the Federal government in implementing any one of these options would be minimal.

The key question to consider in deciding the appropriateness or need for new legislation is will the program described above, which can be implemented within existing authority, be effective? Since the key elements of the above program (standardized test, grading system, etc) will be necessary for the implementation of any mandatory option and since it will be possible to obtain a response very quickly as to the industry's willingness to participate in a voluntary tire labeling program, it is recommended that a final decision on the appropriateness of pursuing new authority await the reaction of industry to the voluntary program, and if the response is positive, then await a measure of the effectiveness of the program. With the economic stimulus as great as it is in this instance, it is possible that most (80-90 percent) of the effectiveness of a mandatory program could be achieved without the need for yet additional government regulations.

However, if a regulatory program becomes necessary, it is recommended that a combination of implementation options 2 and 4 be pursued - mandatory labeling in conjunction with minimum Corporate Average Tire Standards. This combination would provide the maximum consumer information and consumer choice within a range of tires which would still provide assurance that significant fuel conservation would occur.

Attachment 1

The available data indicate:

40 percent of replacement tires are radials,
60 percent non-radials

From general tire industry opinions on average tire wear, the reported life expectancies are:

Radial tires	33,000 miles
Bias belted	25,000 miles
Diagonal	18,000 miles

For the purpose of this analysis we chose to group bias belted and diagonal tires together as non-radials and to assume an average tire life expectancy of approximately 20,000 miles.*

With the wear assumptions, it is reasonable to believe that:

1. If a vehicle were originally equipped with radial tires and all replacement tires were radials then the original tires and 2 replacement sets would be required for the vehicle to achieve the estimated life of 100,000 miles.

2. If a vehicle were originally equipped with non-radial tires then the original tires and approximately 4 replacement sets will be required to reach 100,000 miles.

3. If a vehicle were originally equipped with radial tires, but that the replacement tires were non-radials, then 3 replacement sets will be required for the vehicle to reach 100,000 miles.

Statement 1 may be translated into the equation:

$$2(0.7 - x)T = R \quad (1)$$

Where,

x = the fraction of vehicles where the original radial tires are changed to non-radials

T = the total number of vehicles times four

R = The total number of radial tires required

---

* This assumption probably underestimates the life expectancy of non-radial tires and therefore, this analysis tends to underestimate the extent of radial to non-radial transitions which are occurring. Consequently, the analysis should be conservative in the fuel conservation potential.

Statements 2 and 3 combined, provide the demand equation for the non-radial tires:

$$4(0.3)T + 3xT = B \qquad (2)$$

Where,

B = the number of non-radial tires required

The tire sales data provide the necessary third equation:

$$R = 0.4(R + B) \qquad (3)$$

Equations 1, 2, and 3 may be solved to yield:

$$x = .15$$

That is, 15 percent of the vehicles originally sold with radial tires are converted to non-radials. Consequently, the fraction of total U.S. distance driven on radial tires is:

$$(0.7 - 0.15) + (0.15)(0.33) = 0.60$$

Approximately sixty percent of the U.S. mileage is driven on radial tires, while the remaining 40 percent is driven on non-radials.

References

1/ Gleming D. A. and P. A. Bower, "Tire Testing for Rolling Resistance and Fuel Economy," Tire Science and Technology, TSTCA Vol. 2, No. 4, November 1974.

2/ Yurko, J., "Tire Related Effects on Vehicle Fuel Economy," U.S. Environmental Protection Agency Technical Report, SDSB 79-27.

3/ Thompson, G. D., "Tire Programs - Several Approaches with Significant Potential to Decrease Fuel Consumption," U.S. Environmental Protection Agency Technical Report, SDSB 79-21.

4/ Klamp, W. K., "Power Consumption of Tires Related to How They Are Used," Proceedings of the 1977 SAE-DOT Conference, Tire Rolling Losses and Fuel Economy - An R&D Planning Workshop.

5/ General Motors Corporation Presentations to Environmental Protection Agency at the GM Proving Grounds, Milford, Michigan, February 22 and July 26, 1978.

6/ Thompson, G. D. and M. Torres, "Variations in Tire Rolling Resistance - A Real World Information Need," Proceedings of the 1977 SAE-DOT Conference, Tire Rolling Losses and Fuel Economy - An R&D Planning Workshop.

7/ "Tire Industry Analysis," Modern Tire Dealer, January 1978.

8/ Fisher, T. M. (GM), letter to Charles Gray (EPA), July 25, 1978.

9/ Tarpinian, H. D., G. H. Nubakken, J. Michory (Uniroyal Tire Company), "A Fuel Savings Passenger Tire," Society of Automotive Engineers, Paper No. 790726, 1979.

10/ Newell, T. (EPA) Memorandum to C. Gray (EPA) March 1980.

11/ "Tire Industy Analysis," Modern Tire Dealer, January 1975.

12/ Baker, T. (Uniroyal), Discussions, February 1980.

13/ "Radial Tires: Do They Give Better Mileage?" Road and Track July 1974.

14/ Loo, A. Y. C., Relationship of Tire Rolling Resistance to the Viscoelastic Properties of the Tread Rubber, Tire Science and Technology, TSCA, Vol. 6, No. 3, August 1978.

15/ Night, R. E., Tire Parameter Effects on Truck Fuel Economy, Society of Automotive Engineers, Paper 791043.

16/ Warchol, J. T. and B. L., Collier, "Effects of Inflation Pressure on Various Performance Characteristics of Bias, Bias-Belted and Radial Passenger Tires." Society of Automotive Engineers, Paper 890087.

17/ CFR Title 49, Part 575, Consumer Information Regulations, Section 104, "Uniform Tire Quality Grading Standards."

18/ Schurmann, D., N. Krause, and D. Kinne, "The Influence of Testing Parameters on Exhuast Gas Emissions, Society of Automotive Engineers, Paper 780649.

19/ EPA Public Docket EN-79-8, Central Docket Section (A-130), Comments received in response to the EPA Proposed Voluntary Aftermarket Parts Self-Certification Regulations.

20/ Thompson G. D. and R. N. Burgeson, "Determination of Tire Energy Dissipation Analysis and Recommended Practice," U.S. Environmental Protection Agency, April 1978.

21/ Rolling Resistance Measurement Procedure for Passenger Car Tires, Society of Automotive Engineers Recommended Practice, SAE J1269 November 1979

22/ Costle, D. M. (Administrator of EPA), letter to Jack Watson (Assistant to the President), "Vehicle Fuel Efficiency Program," January 30, 1980.

Low-Energy Dissipation Tires for Heavy-Duty Trucks

Summary

The extensive use of radial tires on the truck fleet could reduce current U.S. fuel consumption by 67,000 barrels per day. The use of advanced technology in tire rubber compounding can provide an additional conservation of 43,000 barrels per day. Also tire innovations such as "wide singles" replacing some current dual tire configurations could reduce consumption by 28,000 barrels per day.

The extensive use of fuel efficient tires by the trucking industry would have little adverse effect on the general U.S. society. For the trucking industry itself the use of fuel efficient tires would either reduce or have very little effect on operating costs because the value of the fuel conserved through the use of efficient tires offsets the greater initial cost of these tires. No supply problems are anticipated.

When considering just the transition to radial tires for the heavy-duty truck fleet, the "cost" is about $0.63 per gallon of fuel saved for intercity operation and about $1.16 per gallon of fuel saved for local operation.

It is recommended that this initiative be implemented through a voluntary tire labeling program supported by an aggressive public information program. If the voluntary labeling program is not effective in realizing the energy conservation potential of this initiative, which is perhaps likely at least for local truck operation, Congress should then require mandatory labeling in conjunction with a significantly increased excise tax (energy inefficiency tax) for the more fuel inefficient tires.

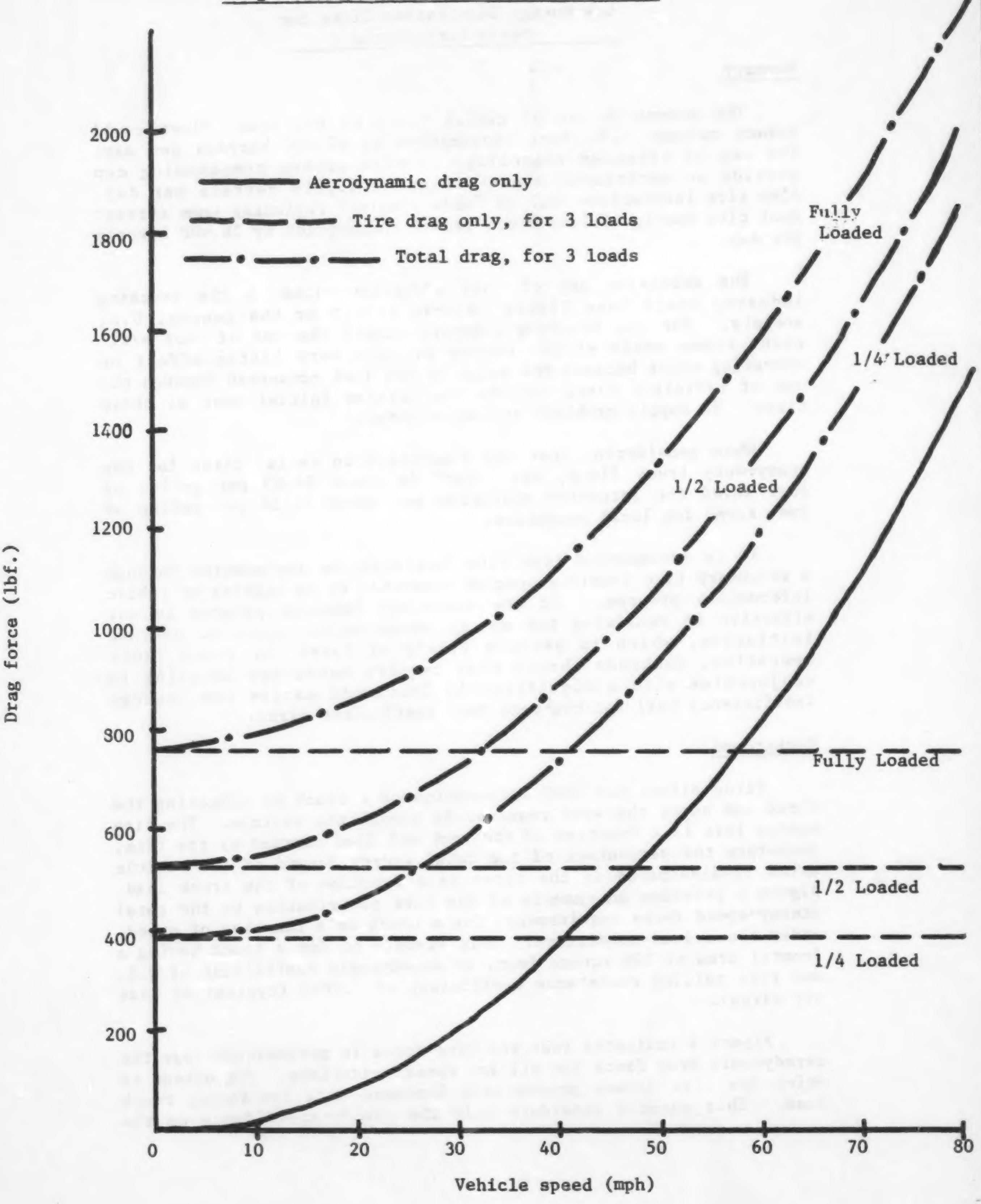
Background

Tires affect the fuel consumption of a truck by affecting the force and hence the work required to propel the vehicle. The tire energy loss is a function of the vertical load carried by the tire, therefore the percentage of the total energy demand of the vehicle which is dissipated in the tires is a function of the truck load. Figure 1 provides an example of the tire contribution to the total steady-speed force requirements for a truck as a function of speed, under three load conditions. This example is for a truck having a frontal area of 100 square feet, an aerodynamic coefficient of 0.9, and tire rolling resistance coefficient of 0.0095 (typical of bias ply tires).

Figure 1 indicates that the tire force is predominant over the aerodynamic drag force for all low speed operations. The extent to which the tire losses predominate increase with increasing truck load. This example considers only the steady-speed force on the

Figure 1

Drag Force (lbf.) vs. Vehicle Speed (mph)



truck. Under transient operation inertial effects of the vehicle somewhat diminish the tire effects. However, long-haul, nearly steady-speed operations account for approximately 81 percent of the miles driven by tractor-trailer trucks and 47 percent of the miles driven by single unit trucks.1/

Fuel Conservation Potentials

At the present time it is reasonably well known that radial tires provide better truck fuel economy.2/3/4/ Somewhat less widely known is the variations among radial tires.5/ These variations provide the basis for two truck fuel conservation potentials. In the first scenario the fuel conservation effect of replacing all current non-radial truck tires is considered. The second scenario considers the additional conservation which might be obtained if optimum low energy dissipation tires were consistently used. The final scenario is one in which some dual tire configurations are replaced with "wide single" tires.

A. Fuel Conservation Potential From the Consistent Use of Radial Tires

For trucks traveling at a steady 55 mph, current truck tire literature reports a fuel economy advantage of 4 to 14 percent for trucks using radial tires over bias ply tires.6/7/ The percentage gain depends on the load carried by the truck; an empty truck will not realize as great a savings as will a fully-loaded truck.

Transient operation (urban driving) of trucks results in a 0-8 percent fuel economy gain using radial tires over bias ply.8/ Again, the exact savings depends on the gross vehicle weight, with the heavier trucks realizing greater savings. The lower fuel economy gain for all trucks in transient operation occurs because of the greater effects of inertial forces in stop-start driving.

For this analysis, eight percent is chosen as a representative average of the fuel conservation potential of radial tires in intercity service, while 4 percent is chosen as a reasonable estimate of the fuel conservation potential of radial tires in transient local service.

Currently about 8 percent of all truck tires are radials, while radials account for 35 percent of the tires in the larger fleet service.9/10/ These data suggest that the radial tire has made a significant penetration into the intercity service tire market, estimated at a total of 25 percent, but has an almost insignificant role in local service. These data together with the current estimated fuel consumption of heavy-duty trucks by type of operation (Table 1), and the potential fuel economy improvements from radials in each form of service, give the over-all estimate of the total heavy truck fuel conservation potential from the consistent use of radial tires, seen in Table 2. The consistent

Table 1

Fuel Consumption of Heavy-Duty Trucks (1000 barrels/day)

Long-haul service	940
Short-haul (transient) service	271
TOTAL	1,211

Data was obtained from the footnoted source using the following assumptions:

1. Intercity operation is primarily diesel fueled (138,700 Btu/gal).

2. Local operation is primarily gasoline fueled (125,000 Btu/gal).

Source: R.E. Knorr and M. Millar, Projections of Direct Energy Consumption by Mode: 1975-2000 Baseline, Energy and Environmental Systems Division Argonne National Laboratory, Report ANL/CNSA-4, August 1979.

Table 2

Fuel Conservation Potential for Consistent Use of Radial Truck Tires (1000 barrels/day)

Intercity service*	56
Local service**	11
TOTAL	67

---

* 8 percent improvement assumed possible for 75 percent of the intercity truck fleet.

** 4 percent improvement assumed for the entire local fleet.

use of radial tires in the truck fleet could reduce U.S. fuel consumption by 67,000 barrels/day.

B. Fuel Conservation Potential of Advanced Technology Radial Tires

It has been reported that it is possible to improve the fuel efficiency of current average radial truck tires by 4 to 5 percent.11/ These data were reported from steady-state tests therefore, consistent with the previous data, it is assumed that 4 percent improvement would be achieved in intercity service while 2 percent improvement would be obtained under local conditions. These estimates are probably conservative since, in the case of light-duty vehicles, advanced technology tires appear to provide a 4 percent improvement in vehicle fuel efficiency during transient operation.12/ Table 3 presents the fuel conservation potential if these low-energy dissipation truck tires were consistently used in the U.S. truck fleet. This table indicates that truck fuel consumption could be further reduced by about 43,000 barrels/day. This reduction would be in addition to the fuel conservation obtained from the general transition to radial tires.

C. Replace some Duals with Wide Singles

It has been predicted that it is possible to reduce the fuel consumption of trucks by replacing dual tires with "wide singles".13/ Also, the feasibility of such tires have been demonstrated.14/ The single tire has approximately one-half of the tire side wall energy dissipation of the two tires it replaces and therefore reduces the vehicle fuel consumption.

In the case of typical large trucks with ten tractor tires and 8 trailer tires as shown in 'a' of Figure 2, eight of the tires could be replaced with 4 wide singles in either configuration b or c of Figure 2. It has been estimated that this would reduce the rolling resistance of the vehicle by 40 percent. This is considerably greater that the rolling resistance improvement associated with a change from non-radial tires, therefore a fuel conservation potential of 6 percent should be achieved.

It is difficult to estimate the national aggregate fuel conservation which might be associated with a general transition to this type of tire, because of the difficulty in estimating the number of vehicles for which this transition would be appropriate. However, if one-half of all trucks in long-haul service could use such tires to replace duals on the heavily laden axles approximately 3 percent of the long-haul fuel consumption, or 28,000 barrels per day could be conserved.

The total potential fuel conservation from the above conservation strategies is given in Table 4, together with the total accumulated potential conservation. This indicates a total fuel conservation of 17,000 barrels per day is possible in 1981, in-

Table 3

Fuel Conservation Potential of Advanced Technology Radial Tires (1000 barrels/day)

Intercity service*	38
Local service**	5
TOTAL	43

---

* 4 percent improvement assumed for the entire intercity fleet.

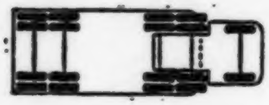
** 2 percent improvement assumed for the entire local fleet.

The above improvements are in addition to the basic non-radial to radial conservation.

Figure 2

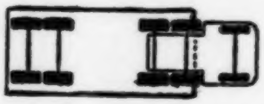
Truck Tire Configurations Using Wide Singles to Replace Duals

a. Present 18-wheel configuration:



Replace 8 tires with 4 wide singles:

b.



or

c.

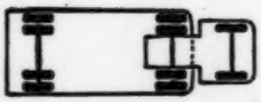


Table 4

Fuel Conservation Potential of Improved Truck Tires
(1000 Barrels per day)

Year	Transition to Radials	Transition to Advanced Technology Efficient Tires	Wide Singles	Total
1981	17	--	--	17
1982	34	--	--	34
1983	50	11	--	61
1984	67	22	--	89
1985	67	32	7	106
1986	67	43	14	124
1987	67	43	21	131
1988	67	43	28	138

A four year linear transition is assumed for the introduction of each technological advance.

creasing to 138,000 barrels per day in 1987.

Cost to Implement

There are three potential costs for any program to reduce truck fuel consumption through more fuel efficient tires; the costs to the consumer, costs to tire manufacturers, and the cost to the government to administer the programs. These costs will vary according to the proposed action and implementation option chosen. The cost to the consumer is generally a net savings or at least no cost growth because of the reduced fuel consumption. The cost to the manufacturer strongly depends on the proposed action, but generally these costs are not great for those actions which may be proposed for near term implementation. The costs to the government depends primarily on the implementation option chosen, however, in all instances this cost is minor compared to the potential national benefits.

A. Cost to the Truck Operator

The cost to the truck operator is primarily dependent on the action taken. Three scenarios will be considered, a transition to current radials, a transition to advanced radials, and the use of "wide singles" to replace dual tires.

1. Transition to Radial Tires

When considering a transition to radial tires, the cost to a truck operator obviously depends on the type of truck, and the nature of the truck operation. Table 5 presents the estimated tire and fuel operating cost with either radial or bias ply tires for an "18 wheel" tractor trailer used in intercity service for 500,000 miles. Also presented are the operating costs for a lighter truck used in local service for 250,000 miles. The calculations supporting this table are presented in Attachment I. The analysis assumed equal tire lives for both tire types.15/ To the extent that radial tires may provide longer services, this would provide a greater estimated cost savings for the radial tire.

The magnitude of the estimated cost savings for intercity tractor trailer use with radials indicates that radial tires should clearly be cost effective for this type of service.

In the case of local service, the magnitude of the predicted cost savings is within the estimation accuracy. Therefore, in local service the use of radial tires may not provide significant total cost savings. This implication appears to be supported by data on the use of radial tires. Among large fleet operators, typically engaged in intercity freight transportation, the type of operation which would show the greatest cost advantage from the use of radial tires, 35 percent of these operators report using radial tires.10/ Yet, on the national average only 8 percent of truck tires are radials.9/ This would indicate that very few local

Table 5

Approximate Tire and Fuel Operating Costs ($)

	Intercity Service (500,000 mi)		Local Service (250,000 mi)	
	Radial	Non-Radial	Radial	Non-Radial
Tires	16,500	11,400	7,100	4,780
Fuel	110,000	120,000	57,600	60,000
Total	127,000	131,400	64,700	64,780
Cost Savings with Radials				
	4,400		80	

service operators are using radial tires. Presumably the long haul operator receives a significant cost advantage from radial tires and is using such tires,while the local operator sees little advantage and is primarily using non-radials.

In all types of truck service there is, of course, potential fuel conservation from the use of radial tires. Including the slightly greater petroleum used in the manufacturing and retreading of the radial tires, radials still provide very significant petroleum conservation.

Using the data provided in Attachment I, the "cost" per gallon of fuel saved is about $0.63 for intercity operation and about $1.16 for local operation.

2. Transition to Advanced Radials

In the case of passenger car tires, optimum low rolling resistance tires do not appear to have appreciably higher cost than other radials.16/ Therefore, it is assumed that advanced radial truck tires are currently available or soon will be, at little or no additional cost from current radial truck tires. Consequently Table 6 presents the approximate tire and fuel operating costs when the additional fuel conservation of advanced radial tires are considered.

In the case of advanced radials Table 6 indicates that these tires provide a significant cost savings for all forms of heavy-duty truck service.

3. Wide Singles

The use of "wide single" tires to replace dual tires is presented since it is an attractive long range approach which has been demonstrated.13/14/ However, since these tires are only available in limited sizes and since vehicle modifications might be required, detailed cost estimates are not attempted.

From the standpoint of the tire alone, this approach should be very cost effective. The wide single is able to support the load of two current tires by increased tread width and increased inflation pressure. Neither of these construction changes should greatly affect the tire cost. Therefore, use of "wide singles" should both reduce tires costs as well as significantly reduce fuel consumption and consequently be very cost advantageous.

B. Cost to the Manufacturer

The cost to tire manufacturers would depend on the action taken and the implementation option.

1. Transition to Radial Tires

If a simple transition to radial tires occurs this will have

Table 6

Approximate Tire and Fuel Operating Costs ($)

	Intercity Service (500,000 mi)		Local Service (250,000 mi)	
	Radial	Non-Radial	Radial	Non-Radial
Tires	16,500	11,400	7,100	4,800
Fuel	105,600	120,000	56,400	60,000
Total	121,000	131,400	63,500	64,800
Cost Savings with Advanced Radials				
	10,400		1,300	

little effect on the costs of tire manufacturers who are currently producing radial tires. However, to a tire manufacturer not currently producing radial truck tires the cost of converting to radial tires could be quite expensive.17/ This is discussed further in the section on impacts.

2. Advanced Radials

Consistent use of optimum or advanced radial tires can only occur if such tires can be identified. This requires a testing and grading program for tire rolling resistance. The major tire manufacturers are already conducting rolling resistance tests as part of their programs to develop and promote improved tires. Therefore, for many tire manufacturers little additional test burden would be expected and therefore little cost would be incurred.

In the case of the smaller independent manufacturers, some test costs would be incurred unless the implementation option was a voluntary program which provided some "default" tire grade option. Even if the small manufacturer were required to conduct tire rolling resistance tests, the cost is estimated to be small. Several independent test laboratories have indicated willingness to conduct passenger car rolling resistance tests for a cost of about $80 per tire. There is little reason to believe that measurements of truck tire rolling resistance would be appreciably more expensive. Therefore, assuming a test cost of $300, if a manufacturer required 100 tests of each tire line, implementation of the program would only incur a test cost of approximately $100,000.

3. Wide Singles

The adoption of use of "wide singles" by the truck industry would cause some cost to the tire manufacturing industry since limited manufacturing capacity for these tires currently exists. Since these tires are not fundamentally different from current radial tires the transition costs to produce these tires would not be appreciably greater than the costs in transition to radial tires.

C. Government Costs

The costs to the government will depend on the implementation option chosen. For example, if an excise tax approach, which only differentiated between radials and bias ply tires, is chosen there would be almost no administrative cost.

Any programs which would promote optimum tires on the basis of rolling resistance measurements would require some testing laboratory to act as the "official" test site for correlation and comparison purposes and to verify, if necessary, the tire energy dissipation claims made by tire manufacturers.

If a laboratory were established for the purpose of administering a truck tire program, it is projected that the government implementation effort could be accomplished with an equivalent of 20 or fewer positions. This cost could be significantly reduced if any truck programs were conducted by the same test facility which also conducted a light-duty vehicle tire program.

Supply

The difficulty of supply depends on the implementation scenario and the desired rate of implementation. Scenario A only requires a greater shift of production from non-radials to radial tires. Particularly in this instance, there should be few supply problems since the U.S. tire industry is currently producing radial truck tires and also has considerable experience in manufacturing radial passenger car tires.

A complete transition to radial truck tires would require less than 30 million additional radial truck tires. By comparison the tire industry was able to increase radial passenger car tire production from very few in 1973 to almost 70 million in 1975.[18/] This past performance of the tire industry indicates that the industry should be able to respond to the increase in radial truck tire demand which would occur if radial truck tires were consistently used.

Even in the case of the proposed advanced technology tire for the mid-1980's, supply problems are not foreseen since it is predicted that the advancements will come from changes in rubber compounding, thread depth and inflation pressures and that these tires will not be fundamentally different than the radials which are now in common use.

Currently, wide singles are not available from diverse sources, therefore there are obvious supply problems in this instance. However, these tires are being manufactured and they are not fundamentally different from current radial tires. The use of such tires is considered to be a somewhat longer range approach and therefore there should be adequate time available to solve any supply difficulties.

Impacts

A. Consumer Impact

The impact on the consumer will depend on the scenario and the implementation option. However, for all scenarios, there is either a net savings to the consumer or at least no cost growth. The tendency toward cost savings will increase as fuel costs continue to increase and as radial tires continue to improve. Consequently the only real impact on the consumer which occurs from using radial tires in place of non-radial tires is the initial higher purchase cost of the radial tire.

In the case of the advanced radial there may be some degradation in the wear characteristics of the tire, although it has not been demonstrated that this will necessarily occur.11/ If it is clearly demonstrated that these tires have a significant fuel conservation potential, slightly reduced tread life would not be a major impact on the professional trucker who appears to be conscientiously minimizing his total tire and fuel costs.

In the case of the "wide single" tire there are some potential safety effects which must be considered. For example, failure of the only tire on one side of a single axle trailer could be a significant hazard. For this reason tires of this type were only considered for those applications where a safety "back-up tire" would still exist, such as a tandem axle-dual tire application.

B. Environmental Impact

Any approaches which call for conserving fuel by reducing the energy required to operate the vehicle can be expected to have a positive effect in reducing vehicle exhaust emissions.19/ In general, the effect on diesel particulates and on NOx exhaust emissions will be the most significant. It would be expected that if a 5 to 10 percent reduction in fuel consumption is obtained from low rolling resistance tires, this would be accompanied by a significant reduction of diesel particulates and by a reduction of approximately 10 percent in the NOx emissions from the vehicle.

C. Industry Impacts

Scenario A, which is the essential transition to radials will cause the greatest impact on the tire industry. However, the anticipated increase in the demand for radial truck tires is less than the recent increase in the demand for radial passenger car tires, which the industry accommodated. In addition, the industry already has a large manufacturing capacity for radial truck tires.

One very important difference exists between radial truck tires and radial passenger car tires; that is, the radial truck tire is not credited with significantly longer expected tire life. Consequently, an increase in radial truck tire production does not imply a significant decrease in the total truck tire demand. Therefore, since the radial truck tire is more labor intensive to produce than the non-radial tire, a transition to radial truck tires will probably increase the total industry labor required. Also since radial tires are more expensive, they are presumably sold with a higher profit margin. Consequently, the transition to radial truck tires is considered likely to have some beneficial impacts on the aggregate tire industry.

The one element of the tire industry which may be severely affected is that small segment of the tire industry which is not currently producing radial tires. Many of those companies or those manufacturing facilities which are now producing only non-radial tires would require transition to radial tire production or would be forced to concentrate on tire markets other than for trucks. One smaller tire manufacturer has indicated that this could have a significant negative effect on its corporation because of the capital investment required to convert to radial tire production.17/

In regard to transition to advanced or optimum radial tires little differential within the tire industry is expected. Any manufacturer currently producing radial tires should be able to produce advanced optimum tires with the same facilities.

Implementation Options

Low rolling resistance tires may be promoted by encouraging or requiring radial tires as a generic type. This may be a satisfactory initial approach, however, to encourage optimum or advanced low rolling resistance tires, there must be a standardized, reasonably accurate test procedure to determine the rolling resistance of a given tire design. In the case of passenger car tires, EPA began work over two years ago in coordination with the automobile and tire manufacturing industries to develop an acceptable rolling resistance measurement procedure. The coordination has been achieved through the Society of Automotive Engineers (SAE), and has resulted in acceptable rolling resistance test procedures.20/21/ This test procedure is adaptable, with minor modifications, to truck tires.

The test procedure can be used to promote the use of fuel efficient truck tires in four basic ways. These are:

1. Public Information Campaign

A public information campaign could be conducted by publicizing tire test results from government or contractor laboratories.

This approach has the advantage that results could be published in 1980 or 1981. The disadvantage is that the burden of identifying the tire which corresponds to the published results of the test tire rests with the truck operator. If the tire industry so desired it could easily defeat this type of information program by frequently changing tire model or brand names and descriptions.

2. Tire Labeling

A more positive approach would be for tire manufacturers to test representative tires from each of their basic tire lines to establish the rolling resistance characteristics of the particular tire design. This rolling resistance information would then be required to be affixed to each tire in the form of a label indicating the relative fuel efficiency of the particular tire type.

This concept could, for example, group tires into three or four different rolling resistance classes or grades (i.e., Grade A, B, C, and D). The truck operator would know that a Fuel Economy Grade "A" tire had the best fuel efficiency characteristics and could use this factor in his consideration of which tire type to purchase. The relative fuel savings of one grade as compared to another could be made available through the tire retailers or independently by the Federal government, much as the automobile fuel economy mileage guide is now made available by the Department of Energy and the Environmental Protection Agency.

Any public information-labeling program would result in an increased use of low rolling resistance tires. However, there would still be an incentive on behalf of the truck operator to purchase high energy dissipation non-radial tires because of their lower initial cost.

3. Energy Inefficiency Tax

On the basis of rolling resistance tests conducted by the tire manufacturers and/or the Federal government, the tires could be taxed on the basis of their relative inefficiency. Such a tax could be structured so as to raise the price of the fuel inefficient tires to be as high as the price of the fuel efficient tires. This would likely result in the consumer purchasing the more fuel-efficient tire since the fuel-inefficient tire would no longer have an initial cost advantage.

The energy inefficiency tax could be structured to be in combination, or as a replacement of, the present excise tax. The current excise tax effectively taxes the petroleum used in the construction of the tire by taxing the quantity of rubber in the tire. The more appropriate tax would be one directed toward taxing the total petroleum consumption associated with the tire. That is, both the petroleum used in the manufacture of the tire and "wasted" during subsequent use on an average vehicle would be taxed.

The energy inefficiency tax could be structured so that the current excise tax would be waived on all fuel efficient tires, while fuel inefficient tires could be taxed at several times the rate of the present excise tax. Few consumers would wish to pay an expensive tax for the "privilege" of purchasing fuel inefficient tires. Consequently, this approach would provide an inherent incentive for the tire manufacturers to develop more fuel-efficient tires.

4. Energy Efficiency Standard

Each tire manufacturer could be required to produce tires which: a) are all required to meet a minimum rolling resistance standard, or b) on a corporate average basis would meet a specified rolling resistance value. With either of these approaches, there would be full assurance that the full potential energy savings available through the use of low rolling resistance tires in the replacement tire market would be achieved.

Recommendations

Programs which may be accomplished under existing authority are likely to be effective much sooner than any programs which require legislative action and subsequent rulemaking proceedings. Therefore, it is recommended that implementation Option 1, the Public Information Program, and implementation Option 2, a voluntary Tire Labeling Program, be pursued. EPA has, in fact, recently committed to implement this approach for passenger car tires. Truck operators appear to be selecting radial tires in those applications where there is clearly net economic advantage to these tires. Consequently an information program and labeling system will promote increased use of radial truck tires in long-haul service and will also promote development and use of advanced radial tires.

However, the analysis of current data indicates that there is little total cost advantage of radial tires in short-haul service and radial tires are generally not used in this application. Therefore, information programs may not promote significant use of current radial tires in the short haul service even though such use does provide significant potential petroleum conservation.

In order to encourage the use of radial tires in all forms of truck service it is recommended that implementation Option 3, an Energy Inefficiency Tax, be considered as an approach to reduce the cost differential between radial and bias tires and thereby make radial tires cost effective on all truck service. This tax could be based only on the radial versus non-radial generic tire types or could be based on measurements of the tire energy dissipation.

In the event that a mandatory program is pursued, such as Option 3, the choice among the latter three implementation options is primarily a choice of policy preference. Since any of these options probably require legislative action, the final policy choice rests with Congress. Any one of these three basic options could be implemented in the near term. The cost to the Federal government in implementing any one of these options would be minimal.

Attachment I

Cost of Vehicle Operation - Radial versus Non-Radial

The cost of vehicle operation with radial tires versus that with non-radial tires is simply the tradeoff between the higher inital purchase price of the radial tire versus the fuel conservation potential of the radial tire. An essential aspect of such a calculation is estimates of the life expectancies of the two tires. It is difficult to obtain good comparative data on the tire life expectancies, therefore, the estimates of tire life expectancies from the literature, Table A-1, are used in the following calculations.*

The operating costs of a heavy-duty truck in intercity operation and a heavy-duty truck in local operation can be estimated on the basis of these tire life expectancies.

A. Intercity Operation

In the case of intercity operation a typical vehicle would be a heavy tractor trailer; the typical "18 wheeler" with one drive axle is considered. This vehicle is shown schematically in Figure A-1. Assuming one drive axle, there are 4 non-driven tires and 4 driven tires. Operation of the vehicle for 500,000 miles will therefore require, based on the tire life estimate of Table A-1, 14 non-driven tires and 16 driven tires. Very nearly equal number of radial or non-radial tires would be required and therefore, it is assumed that a total of 30 tires of either type will be required. Each tire is assumed to be retreaded twice, therefore, 60 retreads will be required. The estimated total tire cost for 500,000 miles of operation using the tire cost estimates of Table A-2 would be:

	Initial Cost/Tire	Retread Cost/Tire	Total Cost
Radial	$350	$100	$16,500
Bias	$200	$ 90	$11,400
Cost Difference			$ 5,100

A truck of this type would be expected to have a fuel consumption of about 5 mile/gallon in intercity service.** Therefore,

---

* D.A. Hunter and W.D. Lee, A Study of Technological Improvements to Optimize Truck Configurations for Fuel Economy, DOT-TSC-OST-75-46.

** R.E. Knorr and M. Millar, Projections of Direct Energy Consumption by Mode: 1975-2000 Baseline, Energy and Environmental Systems Division Argonne National Laboratory, Report ANL/CNSV-4, August 1979.

Table A-1

Medium and Heavy-Duty Tire Life Estimates
(Miles)

	Driven Tires	Non-Driven Tires
Initial Tire Life		
Radial	45,000	200,000
Bias Ply	56,000	180,000
Retread Radial	2	2
Bias Ply	2	2
Total Life		
Radial	125,000	500,000
Bias Ply	125,000	450,000

Source: D.S. Hunter and W.D. Lee, "A Study of Technological Improvements to Optimize Truck Configurations for Fuel Economy, DOT-TSC-OS7-75-46.

Figure A-1

Intercity heavy-duty truck: 18 wheels, 1 drive axle
4 driven tires, 14 non-driven tires

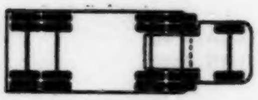


Figure A-2

Local operation heavy-duty truck: 10 wheels
4 driven tires, 6 non-driven tir

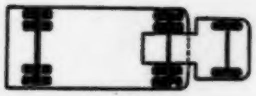


Table A-2

Heavy-Duty Vehicle Tire Cost Estimates

Original Purchase	
Radial	$350
Bias	$250
Retread	
Radial	$100
Bias	$ 90

Cost data were obtained from telephone conversations with local tire dealers. The initial purchase costs were increased slightly above the prices usually quoted to account for the following factors:

1. Tires for the front (steering) wheels are generally more expensive.
2. The following analysis assumes tire retreading, however this may not always be possible because of tire carcase damage.

over 500,000 miles of service , the fuel costs would be:

Fuel Costs (500,000 miles)

Fuel Consumption	Cost($1.20/gal.)
100,000 gal.	$120,000

The cost savings from the fuel conserved through the use of radial tires is consequently:

Fuel Cost Savings from Radial Tires (8%)

$9,600

The net associated operational costs are therefore, the fuel savings minus the higher initial costs of the radials.

Fuel Savings	$9,600
Increased Initial Cost of Radial Tires	$5,000
Net Cost Savings	$4,600

B. Local Operation

A typical heavy-duty truck in local operation is assumed to be represented by Figure A-2, where the truck is assumed to have 4 driven tires and 6 non-driven tires. Using the tire life estimates of Table A-1, this vehicle will require approximately 6 non-driven tires and 18 driven tires, a total of 14 tires and 22 retreads for 250,000 miles of service.

The tire costs are therefore:

	Initial Cost/Tire	Retread Cost/Tire	Total Cost
Radial	$350	$100	$7,100
Non-Radial	$200	$ 90	$4,780
Cost Difference			$2,320

The heavy-duty truck of this example is primarily used in local, short haul service. In this use a fuel economy of 5 miles/gallon is reasonable even though the vehicle is typically lighter than the intercity heavy truck since this vehicle is used in highly transient operation and is typically gasoline fueled. The fuel consumption costs, and savings with radial tires for 250,000 miles operation, would be:

Fuel Cost Savings with Radial Tires:

Total Fuel Consumed (5.0 mi/gal.)	Fuel Costs ($1.20/gal.)	Savings with Radial Tires (4 Percent)
50,000	$60,000	$2,400

The net cost savings with radial tire is:

Fuel Cost Savings	:	$2,400
Initial Higher Cost of Radial Tires	:	$2,320
Total	:	$ 80

The difference is too small to be significant. Several factors could, however, make radial tires more cost effective. As the cost of fuel increases, there will be a greater cost savings from conservation approaches. Also there is some opinion that current radial heavy truck tires have longer tread life than non-radial heavy truck tires. If this is now occurring, then the initial cost disadvantage of the radial heavy truck tire will be offset by the longer tread life, as is the case in light-duty vehicles, and the conserved fuel will become a significant net savings.

References

1/ MVMA Motor Vehicle Facts and Figures, 1979, p. 58.

2/ The DOT/SAE Truck and Bus Fuel Economy Measurement Conference Report, Society of Automotive Engineers, 1975, p. 2.D.2.

3/ The DOT/SAE Truck and Bus Fuel Economy Measurement Study Report, Society of Automotive Engineers, 1976, section 10.

4/ D.B. Shonka, et al., "Transportation Energy Conservation Data Book," Oak Ridge National Laboratory, February 1979.

5/ "Radial Ply Truck Tires Increase Fuel Economy," Automotive Engineering, January 1980, Society of Automotive Engineers, p. 69.

6/ "Effects of Goodyear Unisteel Radial Ply Tires on Fuel Economy," Goodyear, Inc., 1975, p. 16.

7/ "Tire Testing for Rolling Resistance and Fuel Economy," Gleming and Bowers, SAE paper # 750457, 1975, p. 13-14.

8/ "A Study of Technological Improvements to Optimize Truck Configurations for Fuel Economy," Hurter and Lee, DOT-TSC-OST, 1975, p. 5-43.

9/ "Your Marketplace," Modern Tire Dealer, February 7, 1980, p. 27.

10/ "Big Fleets Move to Radials," Diesel Equipment Superintendent, June 1979, p. 80-82.

11/ R.E. Knight, "Tire Parameter Effects on Truck Fuel Economy," Society of Automotive Engineers, Paper # 791043.

12/ M. Reineman and G.D. Thompson, "An Investigation of the Fuel Economy Effects of Tire Related Parameters," U.S. Environmental Protection Agency Report, March 1980.

13/ S.K. Clark, "Geometric Effects on the Rolling Resistance of Pneumatic Tires,".

14/ W.L. Giles, "Expanded Applications Wide Base Radial Truck Tire," Society of Automotive Engineers, Paper No. 791044.

References (cont.)

15/ D.A. Hunter and W.D. Lee, A Study of Technological Improvements to Optimize Truck Configurations for Fuel Economy, Department of Transportation, Report No. DOT-TSC-OST-75-46.

16/ T. Newell, (EPA) Memorandum to C. Gray (EPA), March 13, 1980.

17/ EPA Public Docket EN-79-8, Central Docket Section (A-130), Comments received in response to the EPA Proposed Voluntary Aftermarket Parts Self-Certification Regulations.

18/ "Tire Industry Analysis," Modern Tire Dealer, January 1978.

19/ K.J. Springer, Characterization of Sulfates, Odor, Smoke, POM and Particulates from Light and Heavy-Duty Engines - Part IX, Report No. EPA-460/3-79-007.

20/ G.D. Thompson and R.N. Burgeson, "Determination of Tire Energy Dissipation Analysis and Recommended Practice," U.S. Environmental Protection Agency, April 1978.

21/ "Rolling Resistance Measurement Procedure for Passenger Car Tires," Society of Automotive Engineers Recommended Practice, SAE J1269, November 1979.

Fuel Efficient Engine Oils

Summary

If all passenger cars and light trucks used the best performing of the currently available fuel efficient engine oils, a fuel savings of between 200,000 and 320,000 barrels/day would result.

The cost to the government to ensure that replacement engine oil sold in the U.S. is of a high-grade fuel efficient type would be very small. The cost to the consumer would be a net savings (about 30 dollars between oil changes) because of the reduction in the vehicle fuel consumed. The "cost" of the fuel saved is about 13 cents per gallon. The implementation of this initiative would also reduce the vehicle manufacturer costs of meeting the corporate average fuel economy standards since they could then be allowed to use fuel efficient oils in their compliance test vehicles.

There are no expected supply problems or adverse impacts associated with the use of fuel efficient engine oil.

It is recommended that this initiative be implemented through a voluntary oil labeling program supported by an aggressive public information program. If a voluntary labeling program is not effective in realizing the energy conservation potential of this initiative, Congress should then require mandatory labeling in conjunction with minimum Corporate Average Oil standards.

Background

Fuel is consumed by vehicle engines to overcome air drag, to accelerate the vehicle, to increase the altitude of the vehicle (climb hills), to power engine accessories, and to overcome drivetrain and internal engine friction. The friction which must be overcome in order to power a vehicle is primarily in the engine, the transmission, the differential and in the wheel bearings (tire rolling resistance is considered separately). Lubricants are used to reduce friction, reduce wear, and to some degree to provide a cooling media to the lubricated components. Engine oils, transmission lubricants and differential lubricants are the primary ones of concern from an energy conservation viewpoint.

There has been an increased amount of interest in fuel efficient lubricants by the automobile industry and the petroleum industry in the past several years, as part of the national objective to improve automobile fuel economy. Much of this work has been focused on the development of test procedures to evaluate fuel efficient lubricants, and to what extent the fuel economy performance of new cars can be improved in order to meet the new car fuel economy standards. Relatively little has been done to evaluate the potential conservation benefits of using more fuel efficient lubricants in the entire in-use vehicle fleet.

Fuel Conservation Potential

Of the three types of lubricants (engine oil, transmission lubricant, and differential lubricant), engine oil is most important. This is because engine oil is changed more frequently than the other lubricants, and the potential fuel economy gains from fuel efficient engine oils may be somewhat larger than the gains due to improvements in the other lubricants. Therefore, primarily because of the faster and easier implementation and the expected greater energy significance, the consideration of fuel efficient lubricants in this analysis will be restricted to fuel efficient engine oils.

There are two functional classes of lubricant improvements: viscosity reduction, whose benefits derive from lower viscous drag and pumping losses; and friction modification, which reduces rubbing friction in the oil film between engine surfaces. In product terms, synthetic oils may be considered a third category, exhibiting functional reductions in viscosity or friction or both.

Low-viscosity oils are generally "lighter," more refined oils. A CRC report1/ indicates a fuel economy change on the order of 1 percent per viscosity grade change.

A GM report2/ equates a 67 percent reduction in viscosity to a 30 percent reduction in overall mechanical friction, which in turn corresponds to a 5 to 6 percent gain in steady-state (30-55 mph) vehicle fuel economy. Amoco3/ reports a 90 percent reduction in viscosity to produce a 6 percent fuel economy gain.

Limitations to viscosity reduction include concerns for engine wear rate, engine cleanliness, increased oil consumption, and refiners' capacity to produce enough acceptable light stocks. For these reasons, many (including some auto manufacturers) prefer the friction modification route for improved oils.

Friction modifiers include colloidally-suspended solids, such as graphite or molybdenum compounds, and oil-soluble additives, such as oleates, sperm oil, tallow, etc. The CRC report arrives at average fuel economy improvements from 1 to 3.5 percent for steady-state and cyclic driving vehicle tests, and 4.9 percent for field tests, of friction-improved oils. The field improvements are higher, according to this report, because actual driving is more severe than the EPA and SAE test procedures, and the friction-modified oils are more effective in severe-duty situations. A taxicab fleet, for example, showed a 8.2 percent improvement due to friction modified oils.

Thus far, friction modifiers have been applied only to multigrade base oils (although they should improve monogrades as well) for marketing reasons: the industry makes monogrades for those users who seek cost savings via the price of the oil, and believes that those consumers who don't buy multigrades--for cost reasons--will similarly avoid costlier friction-improved monogrades. In 1976 and 1977, 40 percent of automotive engine oils were multigrade oils.4/

Of course, viscosity improvement and friction reduction packages can be combined, with nearly additive effects, since their functions are relatively independent. The CRC report cites one source as measuring a 1.6 percent mpg improvement with viscosity reduction, a 1.3 percent improvement with friction improvement, and a 2.5 percent combined effect. Research on combined viscosity improvement and friction modification packages is underway, but proceeding cautiously.

Synthetic oil can be used as a total product, or as a blending additive. One major all-synthetic 5W-20 oil is available, with a measured average 4 percent fuel economy improvement, according to the CRC report. The primary advantages of the synthetics are good low-temperature performance and longer drain intervals; the primary disadvantage is cost.

Table 1 summarizes the measured fuel economy benefits of improved oils from a number of sources.

Figure 1 shows the results of a pilot program with tests conducted according to the Draft American Society for Testing and Materials Fuel Efficient Oils Test Procedure.

As can be seen in Table 1 and Figure 1, there is a wide range of improvement that can be attributed to the use of fuel efficient engine oils. This is attributable, at least in part, to the fact that different oil formulations have been evaluated by different experiments using different test methods. Nevertheless, there appears to be a consensus that the use of fuel efficient engine oils can significantly improve fuel economy.

When considering a good quality SAE 10W-40 oil as the reference, it appears reasonable to expect about a 3 percent fuel economy improvement due to a good quality fuel efficient engine oil. However, when it is realized that less than 50 percent of all automotive engine oils are of a multigrade type, the fuel economy gain in substituting a fuel efficient oil for a monograde oil could be expected to be a 5 to 6 percent improvement. Therefore, for the purposes of the analysis in this initiative, it will be assumed that the substitution of current engine oils by a high-grade fuel efficient oil can save between 3 and 5 percent in fuel economy.

Considering only passenger automobiles and light trucks, the fuel conservation potential for substitution of current engine oils with a high-grade fuel efficient oil is between 200,000 and 320,000 barrels/day based on 1977 fuel consumption figures.

Table 1

Fuel Economy Effects of Improved Lubricants (percent change from SAE 10W-40)

A. Engine Dynamometer Tests

Exxon,5/ friction modifier, at 1250 rpm	9.1 to 12.5%
Amoco,3/ friction modifier,	
single cylinder	0 to 2.2%
six cylinder	-0.7 to +2.9%
eight cylinder	1.7 to 2.6%
synthetic 5W-20, eight cylinder	2.3%
Atlantic Richfield,6/ friction modifier,	
steady speeds, 0.5% graphite	0.5%
1.0% graphite	3.0%
multimode, 0.5% graphite	2.4%
1.0% graphite	5.1%
vis. reduction, steady speeds	0.7 to 1.3%
CRC,1/ average for all oils, all sources, **Engine Tests**	**2.7%**

B. Vehicle Tests, Steady-Speed

Amoco, chassis dyno, 50 mph, 15 cars, friction modifier	-0.5 to 3.2%
Lubrizol,7/ track tests, 1/2 @ 35 mph, 8 cars, 8,000 miles each,	
vis. reduction	1.4%
10% synthetic	1.8%
full synthetic 5W-20	2.3%
[required 1,500 miles to reach full effect]	
General Motors,8/ 14.5 minute dyno cycle, 2 speeds, friction modifier (SAE 5W-30 reference oil	-1.1% to +11.2%

C. Vehicle Tests, Cyclic Driving

Atlantic Richfield, modified 45-minute AMA cycle run 8 times (10-55 mph, 38 mph avg.)

Table 1 (Cont'd)

Fuel Economy Effects of Improved Lubricants (percent change from SAE 10W-40)

C. Vehicle Tests, Cyclic Driving (Cont'd)

1%-graphite friction modifier,		
dyno tests		1.9 to 7.2%
10-mile road route, cold start		6.0 to 7.1%
52-mile road route, hot start		3.5 to 4.2%
[required 600 miles to reach full effect, 900 miles to lose effect after drain]		
General Motors,2/ GM City-suburban cycles, 3 cars		
Hot-start, low-vis. commercial lubes in engine, transmission, rear axle		1%
Hot-start, low-vis. experimental lubes in engine, transmission, rear axle		3.8%
Cold-start, low-vis. commercial lubes in engine, and rear axle		4.8 to 11.0%
University of Michigan,9/ SAE J19082 track tests, 7 cars		
Best friction modifier, 3 cars,		
urban cycle		11%
suburban cycle		4%
interstate cycle		4%
CRC, average, all oils, all sources, SAE J1082 Tests		2.3%
Lubrizol, hot-start EPA dyno tests, 3 cars		
Friction modifier,	EPA City	-1.2 to +2.2%
	EPA Highway	0.3 to 2.3%
Vis. reduction,	EPA City	-0.7 to +1.2%
	EPA Highway	1.0 to 2.8%
Amoco, std. EPA dyno tests, 2 cars		
Friction modifiers,	EPA 55/45	-0.5 to 2.2%
[required 1,500-1,800 miles to reach full effect]		
Exxon, std. dyno tests, 6 cars,		
Friction modifier,	EPA City	0.1 to 10.2%
	EPA Highway	1.9 to 14.9%
	EPA 55/4 (average)	5.5%
General Motors,2/ improved lubes in engine and rear axle		

Table 1 (Cont'd)

Fuel Economy Effects of Improved Lubricants (percent change from SAE 10W-40)

C. Vehicle Tests, Cyclic Driving (Cont'd)

Low-vis. lubes in engine and axle, (3 cars)		
	EPA City	0.5 to 2.9%, 1.7% avg.
	EPA Highway	-0.3 to +2.0%, 0.7% avg.
	EPA 55/45	0.4 to 2.3%, 1.3% avg.
Synthetic in engine, low-vis. in axle, (1 car)		
	EPA City	0.4%
	EPA Highway	2.4%
	EPA 55/45	1.1%
CRC, average, all oil-soluble FM's		
	EPA City	2.3%
	EPA Highway	1.6%
CRC, average, 5W-20 synthetic, 20 domestic cars		
	EPA City	3.2%
	EPA Highway	1.6%
8 import cars, 5W-20 synthetic vs. SAE 40		
	Hot EPA City	4.6%
	Cold EPA City	6.8%
CRC, average, all oils, all sources, EPA 55/45		2.0%

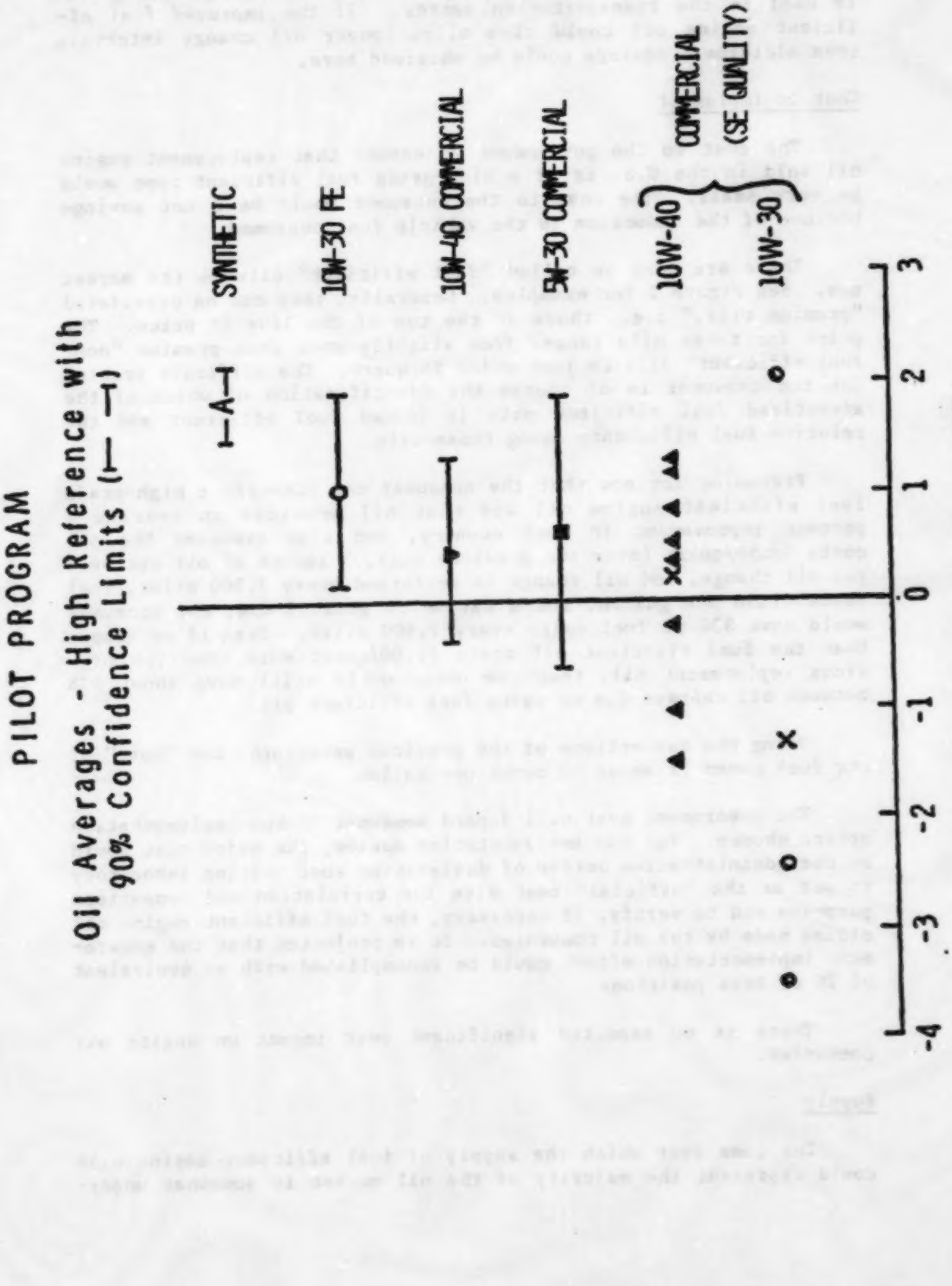
D. Field Tests

Exxon, friction modifier, 19 cars, 6,000 miles		
	Range	0 to 7.1%
	Average	4.6%
[required 1,500 miles to reach full effect]		
Climax Molybdenum,11/ molybdenum disulfide friction modifier:		
7 cars, 102,000 miles		3.4%
10 cars, 395,000 miles		3.7%
23 school buses, 214,000 miles		4.6%
Atlantic Richfield,12/ graphite friction modifier		4.9%

Table 1 (Cont'd)

Fuel Economy Effects of Improved Lubricants (percent change from SAE 10W-40)

D.	**Field Tests 'Cont'd)**	
	CRC, average, all oils, all sources, Field Tests	3.4%
E.	**Rear Axle Lubricants Alone**	
	Ford,13/ lab tests and computer simulations, synthetic vs. SAE 90W	
	EPA tests, 70° F	<1%
	Short trip winter driving	5% (approx.)
E.	**Rear Axle Lubricants Alone (Cont'd)**	
	Edwin Cooper,14/ friction amd modified lube vs. SAE 80W-90,	
	EPA highway test with 50% increase in road load HP	2.0 to 2.2%
	Field tests	3.2%
	General Motors, low-vis. lube (SAE 75W) vs. SAE 90W, 2 cars,	
	30 mph	0.3 to 0.6%
	55 mph	0.6 to 0.8%



PILOT PROGRAM

Oil Averages - High Reference with 90% Confidence Limits (├─┤)

FIGURE 1

Additional benefit, of course, could be expected from the use of fuel efficient oils in heavy-duty gasoline and diesel trucks. Also currently about 68,000 barrels/day of engine lubricating oil is used in the transportation sector. If the improved fuel efficient engine oil could also allow longer oil change intervals then additional savings could be obtained here.

Cost to Implement

The cost to the government to ensure that replacement engine oil sold in the U.S. is of a high-grade fuel efficient type would be very small. The cost to the consumer would be a net savings because of the reduction in the vehicle fuel consumed.

There are many so called "fuel efficient" oils on the market now. See Figure 2 for examples. Generally, they can be considered "premium oils," i.e., those at the top of the line in price. The price for these oils ranges from slightly more than premium "non-fuel efficient" oils to just under $4/quart. The difficult problem for the consumer is of course the identification of which of the advertised fuel efficient oils is indeed fuel efficient and the relative fuel efficiency among those oils.

Presuming for now that the consumer can identify a high-grade fuel efficient engine oil and that oil provides an average 4 percent improvement in fuel economy, and also assuming the oil costs $0.50/quart (over the previous oil), 5 quarts of oil are used per oil change, and oil change is performed every 7,500 miles, fuel costs $1.50 per gallon, and a car which gets 15 mpg, the consumer would save $30 in fuel costs every 7,500 miles. Even if we assume that the fuel efficient oil costs $1.00/quart more than the previous replacement oil, then the owner would still save about $25 between oil changes due to using fuel efficient oil.

Using the assumptions of the previous paragraph, the "cost" of the fuel saved is about 13 cents per gallon.

The government cost will depend somewhat on the implementation option chosen. For any implementation option, the major cost would be the administrative burden of designating some testing laboratory to act as the "official" test site for correlation and comparison purposes and to verify, if necessary, the fuel efficient engine oil claims made by the oil companies. It is projected that the government implementation effort could be accomplished with an equivalent of 20 or less positions.

There is no expected significant cost impact on engine oil companies.

Supply

The time over which the supply of fuel efficient engine oils could represent the majority of the oil market is somewhat uncer-

FIGURE 2

FUEL-SAVING ENGINE OILS

				BASE STOCK		
				SYNTHETIC		
NAME	SAE VIS.	% PHOS.	STATEMENT	PART	ALL	MINERAL OIL
ARCOgraphite	10W-40	0.16	IMPROVED GASOLINE MILEAGE	-	-	X
MOBIL 1	5W-20	0.12	" " "	-	X	-
DELVAC 1 (MOBIL)	30(5W-30)	0.12	" " "	-	X	-
EXXON UNIFLO	10W-40	0.17	CONSERVES GASOLINE	-	-	X
PENNZOIL P.Z.L.	10W-40	0.13*	GAS SAVING	-	-	X
KENDALL SYNTHETIC FORTIFIED	5W-40	0.13*	GASOLINE SAVING	X	-	-
QUAKER STATE STERLING	10W-40	0.13*	ENERGY SAVING	-	-	X
MARATHON ULTRA D	5W-40	0.13*	CONSERVES GASOLINE**	X	-	-
CATO MYSTIK DIMENSION 530	5W-30	0.13*	ENERGY SAVING	-	-	X
AMERICAN PETRO FINA 2001	5W-30	0.13*	INCREASES MILEAGE	X	-	-
IMPERIAL CANADA UNIFLO	5W-30 10W-40	0.13*	SAVES GAS**	-	-	X
VALVOLINE ESP	10W-30	0.13*	ENERGY SAVING	X	-	-
TEXACO HAVOLINE SUPREME	10W-40	0.14	REDUCED FRICTION	-	-	X
AMOCO LDO	10W-40	0.19	IMPROVED FUEL ECONOMY	-	-	X
SKELLY SUPREME PLUS	5W-30 10W-40	0.12*	IMPROVES MILEAGE	X	-	-
GETTY VEEDOL PLUS GETTY GOLD	5W-30 10W-40	0.12*	" "	X	-	
SHELL CANADA SUPER PLUS	5W-30 10W-40	0.16	SAVES GASOLINE**	-	-	X
SHELL CANADA SYNARCTIC	5W-20	0.12	SAVES FUEL**	X	-	-
CONKLIN CONVOY (PARASYNTHETIC MOLY)	10W-50 30	0.13* 0.10	IMPROVES GAS MILEAGE	X	-	-
UNION LONG DISTANCE PURPLE	10W-30	0.12	INCREASES " "	-	-	X
AMS PARA-SYNTHETIC	10W-40	0.13*	IMPROVED FUEL ECONOMY	X	-	-
AMS PARA-SYNTHETIC	15W-40	0.13*	" " "	X	-	-
AMS OIL	10W-40	0.13	" " "	-	X	-
SHELL FIRE AND ICE	10W-40	0.13	NEW GAS SAVING FORMULA	-	-	X
CHEVRON CUSTOM	10W-30	0.13*	FUEL SAVING	-	-	X
SUN MPG	10W-30	0.20	MORE MILES PER GALLON	-	-	X
SUNCO CAM 2 (SEARS)	10W-30	0.20	INCREASES GASOLINE MILEAGE	-	-	X
K-MART DELUXE PLUS	10W-40	0.20	IMPROVES MILES PER GALLON	-	-	X
CHAMPLIN TRANSEASON	10W-40	0.13*	INCREASED GAS MILEAGE	-	-	X
LUBRICHEM	10W-40	-	INCREASES GASOLINE MILEAGE	-	X	-
GULFPRIDE SUPER PREMIUM	10W-40	0.14	FUEL ECONOMY	-	-	X

* LZ CHEMISTRY LIKE X792-51 & 52

** STATEMENT USED IN ADVERTISEMENT, BUT NOT ON CAN

RHK 2/18/80

tain. This is because there are various types of fuel efficient oils currently in production and under consideration. Some fuel efficient oils are made with totally synthetic stocks which raise more supply/leadtime concern than do others which are made with petroleum-based stocks and known additive packages.

Early implementation, however, will probably result in the introduction of oils made with known additives and petroleum-based stocks. It is estimated that such oil could represent the majority of the oils available in the market approximately one year after the start of an implementation program.

Impacts

There are no expected economic impacts of implemention of this initiative. There are also no anticipated environmental or safety impacts.

Implementation Options

In order for fuel efficient engine oils to be encouraged or required, there must be a standardized, reasonably accurate method (test procedure) to predict the fuel economy effect of a given oil. The EPA began work over two years ago in coordination with the automobile and petroleum industries to develop an acceptable engine oils fuel economy test procedure. The coordination has been achieved through the Society of Automotive Engineers (SAE), and the American Society for Testing and Materials (ASTM) and has resulted in an acceptable engine oils fuel economy test procedure.

There are four basic options available to increase the use of fuel-efficient oil. These are:

1. Public Information Campaign

A public information campaign could be conducted by publicizing oil test results from government or contractor laboratories. Current EPA programs could be used to provide data for initiation of such a program.

This approach has the advantage that results could be published in 1980. The disadvantage is that the burden of characterizing all the many engine oils would lie with the government for a full-scale program. If the oil industry so desired, it could easily defeat this type of information program by frequently changing brand names and descriptions. Also, this approach might be misleading in the case of major brand name retails such as Sears, Wards, etc. who probably obtain oils from diverse companies.

2. Oils Labeling

A more positive approach would be for oil companies to test representative oil from each of their basic types to establish the fuel economy characteristics. This information would then be required to be affixed to each can of oil in the form of a label indicating the relative fuel efficiency of the particular oil type. This concept could, for example, group oils into three or four different fuel economy classes or grades (i.e., Grade A, B, C, and D). The consumer would know that a Fuel Economy Grade "A" oil had the best fuel efficiency characteristics and could use this factor in his consideration of which oil type to purchase. The relative fuel savings of one grade as compared to another could be made available through the retailers or independently by the Federal government, much as the automobile fuel economy mileage Guide is now made available by the Department of Energy and the Environmental Protection Agency.

Any public information-labeling program would result in an increased use of fuel efficient oils. However, there would still be an incentive on behalf of the consumer to purchase low fuel economy oils because of their lower cost (i.e., monoviscosity oils).

3. Energy Inefficiency Tax

On the basis of fuel economy tests conducted by the oil companies and/or the Federal government, the oils could be taxed on the basis of their relative inefficiency. Such a tax could be structured so as to raise the price of the fuel inefficient oils to be as high as the price of the fuel efficient oils. This would likely result in the consumer purchasing the more fuel-efficient oil since the fuel-inefficient oil would no longer have an initial cost advantage.

4. Energy Efficiency Standard

Each oil company could be required to produce oils which: a) are all required to meet a minimum fuel economy standard; or b) on a corporate average basis would meet a specified fuel economy value. With either of these approaches, there would be full assurance that the full potential energy savings available through the use of fuel efficient oils would be achieved.

Recommendations

The first recommendation is to proceed with an oil initiative as quickly as possible because of the significant conservation potential.

Programs which may be accomplished under existing authority are likely to be effective much sooner than any programs which require legislative action and subsequent rulemaking proceedings. Therefore, it is recommended that implementation Option 1, the public information program, and implementation Option 2, a voluntary oil labeling program, be pursued. EPA has, in fact, recently committed to implement this approach.15/

In the event of the need for a mandatory program, the choice among the latter three implementation options is primarily a choice of policy preference. Since any of these options probably require legislative action, the final policy choice rests with Congress. Any one of these three basic options could be implemented in the near-term. The cost to the Federal government in implementing any one of these options would be minimal.

The key question to consider in deciding the appropriateness or need for new legislation is, will the program described above, which can be implemented within existing authority, be effective? Since the key elements of the above program (standardized test, grading system, etc.) will be necessary for the implementation of any mandatory option and since it will be possible to obtain a response very quickly as to the industry's willingness to participate in a voluntary oil labeling program, it is recommended that a final decision on the appropriateness of pursuing new authority await the reaction of industry to the voluntary program, and if the response is positive, then await a measure of the effectiveness of the program. With the economic stimulus as great as it is in this instance, it is possible that most (80-90 percent) of the effectiveness of a mandatory program could be achieved without the need for yet additional government regulations.

However, if a regulatory program becomes necessary, it is recommended that a combination of implementation Options 2 and 4 be pursued - mandatory labeling in conjunction with minimum Corporate Average Oil Standards. This combination would provide the maximum consumer information and consumer choice within the range of oils which would still provide assurance that significant fuel conservation would occur.

References

1/ Marshall, "Survey of Lubricant Influence on Light-Duty Vehicle Fuel Economy," Coordinating Research Council Report 502, December 1978.

2/ Goodwin and Haviland, "Fuel Economy Improvements in EPA and Road Tests with Engine Oil and Rear Axle Lubricant Viscosity Reduction," SAE Paper 780596, June, 1978.

3/ Passut and Kellman, "Laboratory Techniques for Evaluation of Engine Oil Effects on Fuel Economy," SAE Paper 780601, June, 1978.

4/ Oil and Gas Journal, August, 1978.

5/ Waddey, et al., "Improved Fuel Economy via Engine Oils," SAE Paper 780599, June, 1978.

6/ Broman, et al., "Testing of Friction Modified Crankcase Oils for Improved Fuel Economy," SAE paper 780597, June, 1978.

7/ Reister and Chamberlin, "A Test Track Comparison of Fuel Economy Oils," SAE Paper 790213, February, 1979.

8/ Caracciolo and McMillan, "Effect of Engine Oil Viscosity on Low-Temperature Cranking, Starting, and Fuel Economy," SAE Paper 790728, June, 1979.

9/ Bennington, et al., "Stable Colloid Additives for Engine Oils--Potential Improvement in Fuel Economy," SAE Paper 750677, June, 1975.

10/ Davison and Haviland, "Lubricant Viscosity Effects on Passenger Car Fuel Economy," SAE Paper 750675, June, 1975.

11/ Risdon and Gresty, "An Historical Review of Reductions in Fuel Consumption of U.S. and European Engines with MoS_2," SAE Paper 750674, June, 1975.

12/ DeJovine, et al., "Consumer Fleet Testing of Friction Modified Motor Oils for Fuel Economy Benefits," NPRA Paper, March, 1978.

13/ Willermet and Dixon, "Fuel Economy - Contribution of the Rear Axle Lubricant," SAE Paper 770835, September, 1977.

14/ Papay, "Fuel Saving Gear Oils," SAE Paper 790745, June, 1979.

15/ Costle, Douglas M. (Administrator of EPA), letter to Jack Watson (Assistant to the President), "Vehicle Fuel Efficiency Program," January 30, 1980.

Improved Engine Efficiency
Through Cylinder Deactivation

Summary

If 60 million in-use vehicles with V-8 engines and with an average useful life remaining of 50,000 miles are modified to disable four cylinders, then from 500 to 700 million barrels of gasoline over the next 10-15 years could be saved, or about 130,000 to 200,000 barrels per day taken over a ten year period.

The cost to the government to certify acceptable modification systems would be small. The exact cost to the consumer is at this time uncertain; however, it is expected that significant net savings would result - an initial installation cost of $100-$175 with an annual savings of about $150. The "cost" of the fuel saved is calculated to be about 24 cents per gallon.

However, it is possible that insurmountable impacts of implementing this initiative exist. Current data indicate substantial negative environmental impact and possible safety problems exist with systems which are simply installed on vehicles without engineering optimization.

The principal recommendation is that the Federal government conduct an engineering optimization study to determine whether the environmental and safety problems which have been identified can be solved.

Background

The size of the engine (maximum torque and/or maximum horsepower) required for use in a light-duty vehicle operated in the United States is set by transient, low speed vehicle operational requirements and the fundamental torque and horsepower characteristics of the internal combustion engine. If vehicle speeds of 100 mph or greater were acceptable, then the horsepower required to maintain these maximum speeds would be the controlling requirement. The engine size is therefore determined by the vehicle acceleration "requirements" of the initial purchaser. Figure 1 shows the engine horsepower requirements for different acceleration rates going from 0 to 60 mph.

The low speed operational requirements which control the selection of the engine are governed by purchaser considerations relating to vehicle operation (and potential driver errors) under situations of traffic merging, passing, trailer towing, etc. Some vehicle purchasers probably obtain a degree of acceleration performance that they feel is sufficiently safe for their driving practices. Certainly, a driver has a sense of what he can expect from his vehicle under conditions of acceleration demand and will make his decision to pass or merge or cross an intersection based on his judgement of risk. With a vehicle which has "poor" ac-

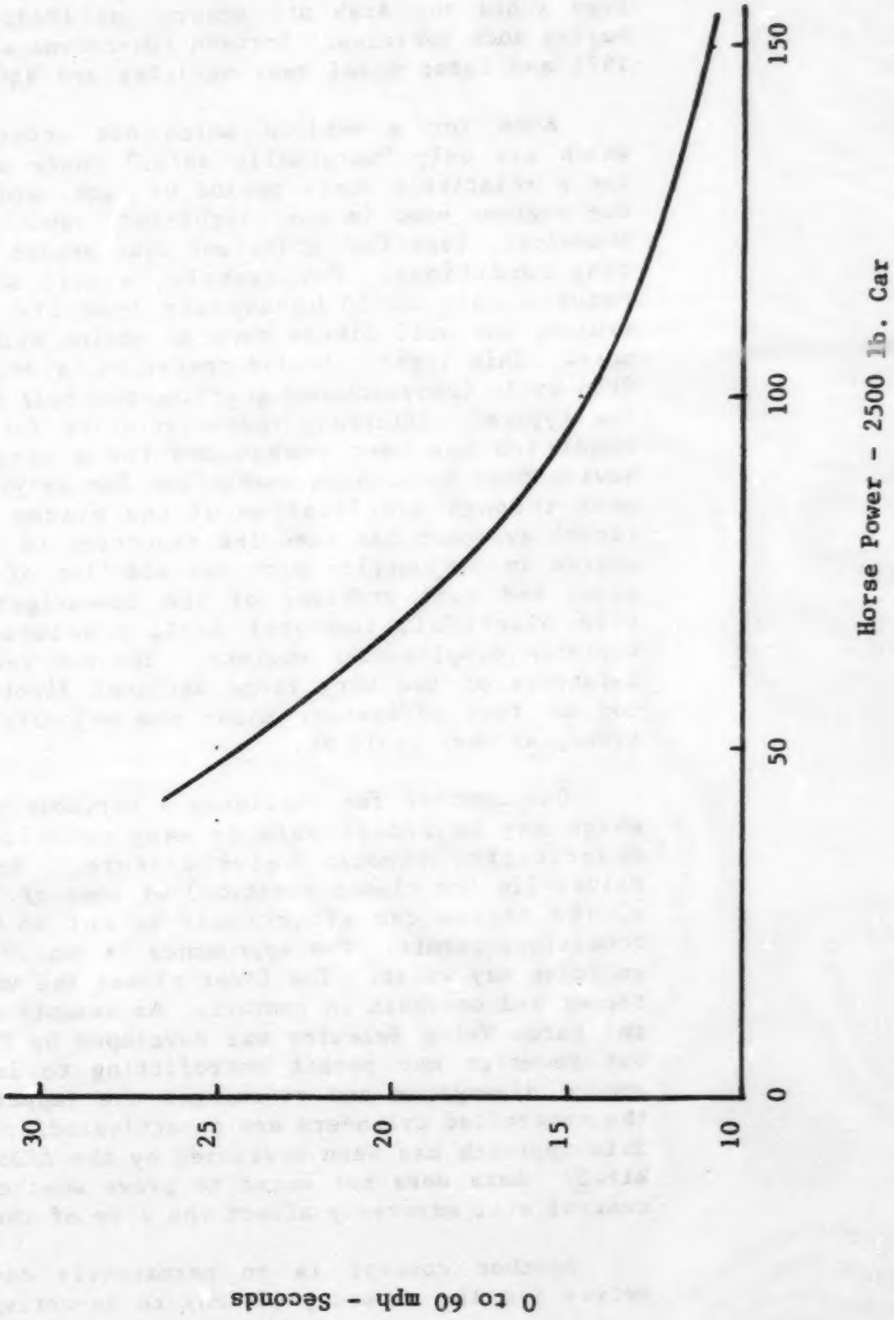


Figure 1

0 to 60 mph Acceleration

celeration characteristics, the driver may be even more cautious, or safe. Many vehicle purchasers probably obtain a degree of acceleration that they "like." These vehicles may have acceleration characteristics sufficient to break traction on the drive wheels during maximum acceleration. This feeling of "power" has been, and perhaps still is, a major driving force in the purchase of automobiles and light trucks. With relatively cheap fuel prices through 1978, buyers of cars and light trucks have been paying a premium for vehicles that have high acceleration characteristics. Even since the Arab oil embargo of 1973, people have still been buying such vehicles. Between two-thirds and three-quarters of the 1973 and later model year vehicles are equipped with V-8 engines.

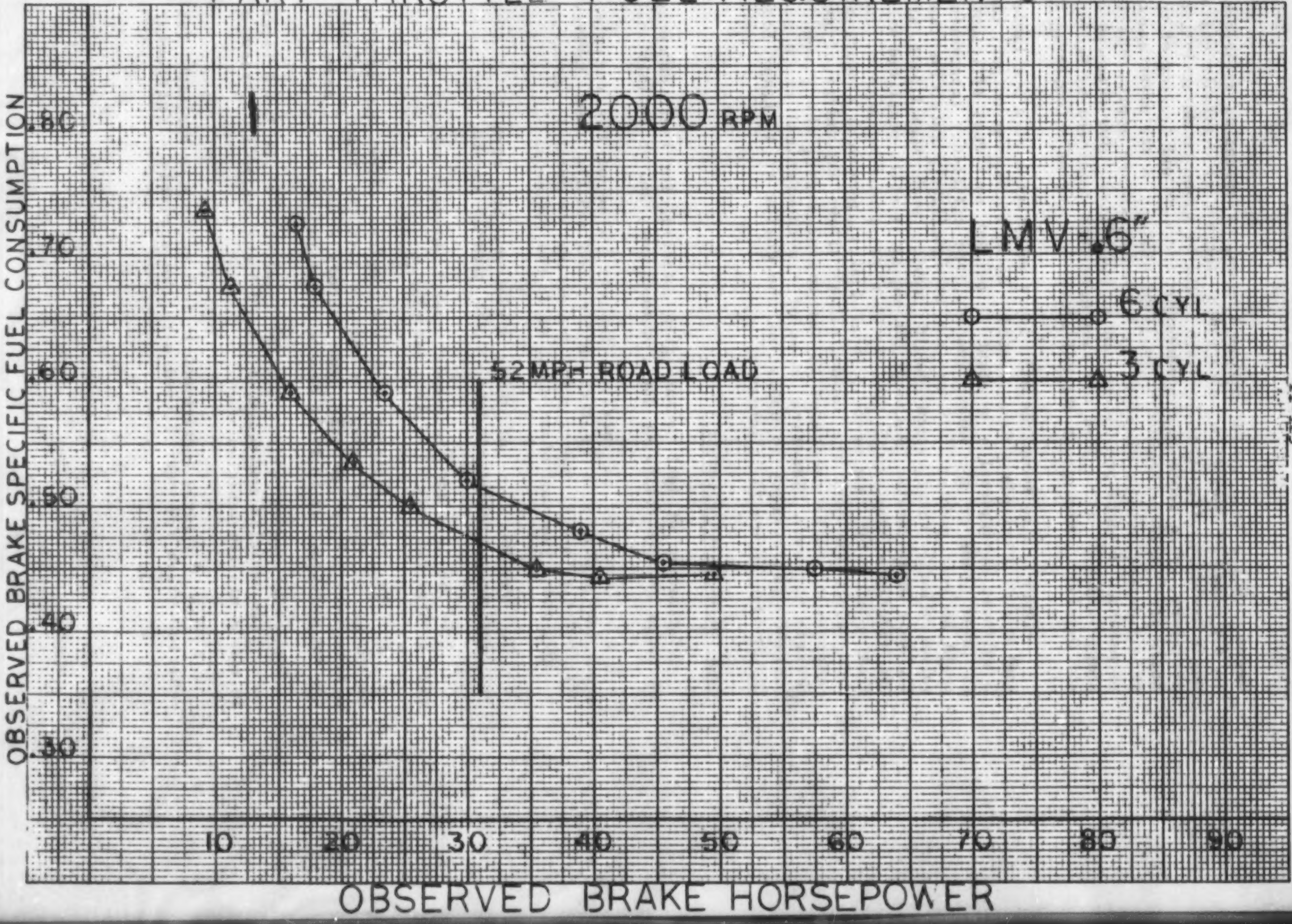
Even for a vehicle which has acceleration characteristics which are only "marginally safe," these acceleration needs exist for a relatively short period of time, and the net result is that the engines used in most light-duty vehicles are much larger and, therefore, less fuel efficient than needed for most vehicle operating conditions. For example, a full size passenger car will require only 20-30 horsepower from its engine even at 55 mph cruise, but will likely have an engine with 150-200 horsepower or more. This lightly-loaded operation is especially inefficient for Otto cycle (conventional gasoline-powered) engines. Figure 2 shows the typical efficiency characteristics for such an engine. This condition has been recognized for a long time, with most work having been focused on mechanisms for varying the engine displacement through modification of the piston stroke. Another more recent approach has been the reduction in the displacement of the engine in conjunction with the addition of a turbocharger. Technical and cost problems of the investigated approaches, coupled with plentiful, low cost fuel, precluded the introduction of variable displacement engines. The net result, therefore, is the existence of the very large national fleet of vehicles which are not as fuel efficient, under the majority of operational conditions, as they could be.

One concept for obtaining a variable displacement engine and which may be retofitable to many existing engines is cylinder deactivation through valve closure. By deactivation of the valves (in the closed position) of some of the cylinders, the size of the engine can effectively be cut in half when operational conditions permit. Two approaches to achieving this goal on in-use vehicles may exist. The first closes the valves while keeping the tappet and camshaft in contact. An example of this approach called the Eaton Valve Selector was developed by Eaton for new vehicles, but redesign may permit retrofitting to in-use vehicles.1/ The second disengages and re-engages the tappet at the camshaft when the controlled cylinders are de-activated/activated. An example of this approach has been developed by the ACDS Company as a retrofit kit.2/ Data does not exist to prove whether or not this means of control will adversely affect the life of the tappets and camshaft.

Another concept is to permanently de-activate some of the valves (in the closed position) to de-activate the cylinders they

FIGURE 2

PART-THROTTLE FUEL REQUIREMENTS



serve. While this would improve the engine operating efficiency in all modes of operation, a permanent forfeit of available engine power would result. Consideration could be given to de-activating cylinders, which based on a compression check or oil fouling of the spark plug, were determined to be least useful. A key advantage of this concept is its simplicity. Several simple approaches to permanently de-activate valves can be identified. Two examples of simple means to accomplish the task have been developed by Professor Gerrish of Michigan State University and the ACDS Company.2/3/

Figure 2 also shows the efficiency improvement of a 6 cylinder engine with 3 cylinders de-activated. At 20 horsepower output, the 3 cylinder configuration is about 17 percent more fuel efficient. At lower loads or for larger engines, the efficiency improvement would be even greater. It may not be immediately intuitive that valve/cylinder deactivation should provide such significant efficiency improvements. Although the engine is still penalized with the frictional losses of the piston's reciprocating motion, including ring and bearing frictional losses, permanent closure of both valves (or just the intake valve) allows any energy of gas compression to be recovered by the engine during the piston's reverse motion. Therefore, most of the theoretical cycle efficiency improvement in operating the engine at a higher load factor (see Figure 2) is achieved.

Fuel Conservation Potential

Estimation of fuel conservation potential for these concepts is based on the following data, assumptions, and/or definitions:

1. Costs of conversion, present value of the vehicle, remaining useful life of the vehicle, and vehicle owner savings attributable to fuel conservation are assumed to preclude inclusion of 1972 model year and older vehicles in the estimate.

2. For purposes of this initiative, the term light-duty vehicles means passenger cars, light pick-up trucks, and vans.

3. The 1973 and later model year light-duty vehicle population is approximately 75 million vehicles.4/

4. Vehicles equipped with V-8 engines offer the largest potential for fuel conservation and are also the least likely to suffer from vibration and other factors which could make the concept unattractive to their owners/operators.

5. Between two-thirds and three-quarters of 1973 and later model year vehicles are equipped with V-8 engines;5/ i.e., between 50 and 56 million vehicles.

6. A 10 percent improvement in fuel economy is projected for vehicles which are retrofitted with the variable displacement

concept,6/ and 15 percent improvement for vehicles retrofitted with the permanent deactivation concept.3/

7. Reduced market penetration of V-8 engines in new vehicles, vehicle downsizing, etc. by vehicle manufacturers and attrition of older vehicles equipped with large engines suggests that the retrofit market for the concept will almost totally disappear in ten years. This situation will impact the amount of capitalization which will be allocated to implementation of this concept.

8. Since some 1973 and later model year vehicles with V-8 engines will have mileage (odometer readings) too high to justify modification by the time this initiative could be implemented, while at the same time new V-8 powered vehicles will continue to be sold (although at a progressively smaller percent of engines) and can ultimately be modified, it is assumed that a total of 60 million vehicles with an average useful life remaining of 50,000 miles are potentially modifiable. It is further assumed that the average on-road fuel economy of these vehicles is 15 miles per gallon.

Variable Displacement Engine Concept. With a 10 percent fuel economy improvement and using the above assumptions, 476 million barrels of gasoline over the next 10-15 years could be saved. This translates into 130,000 bbl/day savings over a ten year period.

Permanent Cylinder Deactivation Concept. With a 15 percent fuel economy improvement and using the above assumption, 714 million barrels of gasoline over the next 10-15 years could be saved. This translates into almost 200,000 bbl/day savings over a ten year period.

Cost to Implement

New capitalization for production and marketing of approximately 60 million variable displacement engine units within six years, with minimization of leadtime, is projected to be on the order of 30 to 40 million dollars for the assembler/marketer of the units and the component supplier companies. This new capitalization burden is relatively small because much of the system will be produced with existing capital equipment. Much, if not most, of the new capitalization will go for final assembly facilities. New capitalization for the permanent cylinder deactivation units is expected to be much less, on the order of 10 million dollars or less.

The ACDS Company has indicated an approximate installed cost of their variable displacement engine concept of between 625 to 725 dollars, and an installed cost of approximately $175 for their permanent cylinder deactivation unit.2/

In addition to the assumptions made previously, assuming an annual vehicle useage of 10,000 miles and an average fuel cost of

$1.50/gal, the annual savings for the variable displacement engine concept would be $100 and for the permanent cylinder deactivation concept would be $150. The variable displacement engine concept would save approximately $500 over the remaining life of the average vehicle, and the permanent cylinder deactivation concept would save about $750 over the average remaining life of the vehicle.

With an estimated installed cost of between $625 to $725, the variable displacement engine concept does not appear, based on the assumptions made herein, to be economically attractive. However, based on an installed cost of $175 for the permanent cylinder deactivation concept, wide spread acceptance of this approach is possible in that the unit would save approximately $150 per year based on the assumptions made herein.

It is projected that the installed cost of both of the concepts discussed will be less than the cost used above. It is projected that the installed cost of a mass produced, minimum cost variable displacement engine concept would be about $300 ($175 for the unit and $125 for installation), and about $100 ($25 for the unit and $75 for installation) for the permanent cylinder deactivation concept.

Using the following assumptions:

1. Average vehicle useful life remaining of 50,000 miles,
2. A 15 percent fuel economy improvement,
3. A base fuel economy of 16 mpg,
4. A permanent cylinder deactivation installed cost of $100;

then, the "cost" of the fuel saved can be calculated to be 24 cents per gallon.

Supply of Necessary Hardware

Because the technology being considered is relatively simple, it is not expected that there will be difficulties with supplying adequate numbers of either the variable displacement engine concept or the permanent cylinder deactivation concept. It is recognized however, that the simplicity of the permanent cylinder deactivation concept, in particular, will facilitate the supplying of sufficient conversion units of this type. It is expected that the majority of the conversions can be accomplished within three years after start, with the remaining conversions completed within an additional two to three years.

Impacts

It is possible that insurmountable impacts of implementing this initiative exist.

There are no expected negative economic impacts associated with implementing this initiative. Individuals that choose to implement this initiative will derive a net economic gain due to fuel savings. New business opportunities will be created through the need to supply 60 million conversion units.

It is likely that without system certification and proper installation, this initiative will have a major negative environmental effect. Results of tests conducted in the past were mixed.3/6/ Recent tests show a higher likelihood of a major increase (up to 10 times) in exhaust emissions.7/8/9/ However, it still may be possible to optimize a unit to a given engine type and avoid significant emission increases.

Another likely negative impact, without system certification and proper installation, is in the area of safety. Utilization of the concept where one-half of the engine cylinders are permanently deactivated could lead to potentially unsafe conditions. The deactivation of one-half the engine cylinders will roughly double previous acceleration times, or cut in half the acceleration rate.7/8/9/ However, as discussed earlier, a driver should quickly become aware of the acceleration characteristics of his vehicle and make his judgements with this in mind. There is a wide variation in vehicle acceleration performances now represented in the motor vehicle fleet, and there does not appear to be a correlation between acceleration performance and likelihood of being involved in an accident. However, without certification and proper installation the engine can be operating in some modes in such a fuel rich condition that driveability is significantly degraded - upon acceleration demand, the car stalls.7/8/9/

Implementation Options

A consumer information campaign could be effective in realizing at least a part of the potential of this initiative. However, there are several reasons why less than the full potential could be expected. First, the significant decrease in acceleration performance associated with the permanent cylinder deactivation concept will be a major negative factor for many people. Second, in order to avoid the significant acceleration performance losses, the variable displacement engine concept represents a very significant cost for the fuel savings to be realized. Third, even though the initial cost of the permanent cylinder deactivation system will be paid for in fuel savings in less than two years, the owners of the older cars to which it is assumed that this concept will be most widely used, are likely to be most sensitive to an additional $100 to $200 investment in their older car.

Economic incentives to encourage the purchase of conversion units could probably be most effective in achieving a substantial portion of the energy conservation potential of this initiative.

While an income tax credit, if large enough, could be effective, the required out of pocket payment for the conversion unit might still discourage many purchases of conversion units. The people who own the older cars, which would be in general more likely to be beneficiaries of this initiative, are also the people who probably can least afford large lump sum out of pocket expenditures. Perhaps then, a better approach would be a purchase discount. This scheme would allow the manufacturer through his outlets to discount the retail price by a given amount (say $20), to be paid for by the Federal Government, as a purchase incentive. In this way, only a limited number of manufacturers/suppliers would have to keep records and submit claims to the Federal Government based upon the number of units sold. Assuming that 60 million units were sold, the total cost to the Federal government to cover a $20 per unit purchase discount would be 1.2 billion dollars over three to six years. This cost would translate into 4 to 6 cents cost per gallon of fuel saved.

Since this incentive involves the need to stimulate the public to purchase hardware that modifies their existing vehicles, as opposed to normal vehicle replacement items such as tires and oils, a regulatory approach would be difficult to implement. A regulatory approach in this situation would require vehicle owners to install conversion kits before they could, for example, receive re-registration of their vehicle. Such an approach would likely stimulate substantial public opposition. Also, such a program would be difficult to administer, for example deciding which vehicles should be subject to the mandatory conversion requirement.

Considering the possible (or even likely) environmental and safety impacts of implementing this initiative without assuring that the systems are optimized to each basic engine type, a development effort seems warranted to establish the full fuel conservation potential of this initiative and to establish whether the environmental and safety problems identified can be solved.

Recommendations

Since such a substantial energy savings is potentially available through the implementation of this initiative (from 500 to 700 million barrels of gasoline), the principal recommendation is that the Federal government conduct an engineering optimization effort to determine: (1) the full energy conservation potential of this initiative and (2) whether the environmental and safety problems identified can be solved.

Assuming that the environmental and safety problems can be solved, and since any of the implementation options discussed would necessitate a conversion system certification procedure, such a procedure should be adopted. In particular, it is recommended that the procedures required under Section 511 of the Energy Policy and Conservation Act (EPCA) for the evaluation of fuel economy retrofit devices be used.

Again, assuming that the environmental and safety problems can be solved, a consumer information program should be instituted, and consideration should be given to the establishment of a Federal economic incentive system. The consumer information program can begin under existing authority; however, the authority to provide economic incentives for the purchase of conversion units would have to be obtained from Congress. The form of the economic incentive sought from Congress could be one that, for any unit that can show a 10 percent or greater fuel economy improvement and no increase in vehicle emissions as evaluated under the regulations established pursuant to Section 511 of EPCA, a $20 purchase discount could be given. The manufacturer of the conversion units sold would submit verification of sales of units to the Federal Government for a reimbursement of the purchase discounts provided.

References

1/ Eaton Corporation, "Eaton Valve Selector," A Pamphlet available from Eaton Corporation, Battle Creek, Michigan, 49106.

2/ "Application for Evaluation of a Fuel Economy Retrofit Device under Section 511 of the Motor Vehicle Information and Cost Savings Act," Automotive Cylinder Deactivation Systems, Inc., September 26, 1979.

3/ "Evaluation of the MSU 4-Cylinder Conversion Technique for V-8 Engines," Technology Assessment and Evaluation Branch, Emission Control Technology Division, Environmental Protection Agency, October 1974.

4/ Estimated from Ward's Automotive Yearbook; 1979.

5/ MVMA Motor Vehicle Facts and Figures; 1979 thru 1968 gives the following installation rates for V-8 engines:

Year	1978	1977	1976	1975	1974	1973
% V-8's	66%	76%	66%	71%	68%	83%

6/ Automobile Emission Control - The Development Status, Trends, and Outlook as of December 1976, U.S. Environmental Protection Agency Report, April 1977.

7/ Barth, Edward Anthony, "Automotive Cylinder Deactivation System (ACDS) - Emissions and Fuel Economy," A Report of the Test and Evaluation Branch of the U.S. Environmental Protection Agency, April, 1980.

8/ Barth, Edward Anthony, "Prototype Cadillac with Modulated Displacement Engine, Emissions and Fuel Economy," A Report of the Test and Evaluation Branch of the U.S. Environmental Protection Agency, April, 1980.

9 Barth, Edward Anthony, "Eaton Valve Selector Emissions and Fuel Economy Tests," A Report of the Test and Evaluation Branch of the U.S. Environmental Protection Agency, April, 1980.

A Fuel Economy Check-Up to Assure Proper Fuel Economy Maintenance

Summary

Existing and planned motor vehicle inspection programs operated by state and local governments are narrowly focused on safety, emissions, or both. These programs provide an opportunity for promoting better fuel economy maintenance. This can be done by adding fuel economy items to the lists of safety and emission items already being inspected, and corrected as necessary, in these programs. Adverse impacts in terms of cost and vehicle owner inconvenience are virtually nonexistent.

Two fuel economy items are especially suited to incorporation into existing vehicle inspection programs. Engine tune checkups for fuel economy can be added to any emissions inspection program. Tire pressure checks and inflation to the tire manufacturer's recommended maximum pressure, the most fuel-efficient pressure, can be added to any safety or emissions program.

Fuel savings would be 56,000 barrels per day in 1983, at a minimum. Possible savings from better fuel economy maintenance of the entire national fleet could be as high as 320,000 barrels per day. Because a substantial fraction of the national fleet is now subject to safety or emissions inspection programs and there are no long lead times in adding fuel economy checks to these programs, some fuel savings could be realized in the first year of this initiative.

The "cost" of the fuel saved when a fuel economy check-up is conducted in conjunction with an existing emissions or safety inspection program is about 9 cents per gallon.

Background

Many vehicles on the road today are not performing as well as they could in terms of fuel economy because they are not kept in fuel-efficient operating condition. There are three problem areas in particular in which better maintenance would restore vehicles towards more fuel-efficient operation, thereby producing fuel savings:

(1) Poor engine tune condition (spark plug wires, spark plugs, air filter, spark timing, carburetor idle air-fuel ratio)

(2) Sub-optimally inflated tires

(3) Misaligned front wheels

All of these problems can be corrected through more frequent and accurate maintenance and more fuel-conscious car care habits on the part of owners. Fuel economy checkups are one way to bring about these improvements in maintenance and care practices.

The existence of annual safety and emissions inspection programs in many parts of the U.S. is an essential element of the background in which initiatives for better fuel economy maintenance should be developed. Vehicle safety inspections have been in existence for many years. Currently 27 states require some form of periodic vehicle safety inspection. In addition, 5 areas in the country now have annual vehicle emissions inspection and maintenance programs, and it is expected that by 1983, a total of 57 such programs will be operational across the country. These safety and emissions programs were and are being developed for motives similar to those behind an initiative for better fuel economy maintenance. The safety and emissions programs are designed to tell owners and mechanics which vehicles need safety or emissions-related maintenance, to give advice on what type of maintenance is needed, to motivate owners to seek the maintenance, and to verify that the maintenance has been performed. The parallel to a program aimed at better fuel economy maintenance is very close. Existing inspection programs can provide conceptual models for establishment of new fuel economy check up programs.

In addition to providing conceptual models, the existing and planned programs of safety and emissions inspections offer an opportunity to implement a fuel economy check-up program for about 40 percent of the fleet at low cost and with short lead time. This could be done by simply adding one or more of the three fuel economy problem areas mentioned earlier to the list of safety and/or emissions items currently being inspected.

The existing and planned emission inspection and maintenance programs already concern themselves with the state of engine tune, since it affects exhaust emissions. Expanding these programs to specifically address the fuel economy aspects of engine tune would be simply a matter of adding one or more additional checks on engine operating parameters. In contrast, existing safety inspection programs do not concern themselves with engine condition and lack the testing equipment and tune-up skills needed for an engine tune checkup program.

Tire inflation pressure can be checked and corrected in any safety or emissions inspection program. (It should also be noted that the National Highway Traffic Safety Administration is presently working on a low tire pressure warning device which is proposed for new vehicles).

Wheel alignment can be checked quickly and cheaply with only a scuff gauge device. This limits wheel alignment checkups to centralized, high-volume safety or emissions inspection stations.

Fuel Conservation Potential

Sufficient data are available to quantify potential fuel savings for the first two of the three fuel economy checks listed earlier: engine tune condition check and tire inflation pressure checks. Although front wheel misalignment is known to occur among in-use vehicles and to adversely affect fuel economy, not enough is known about its frequency and the severity of its fuel economy impact to allow a confident estimate of the fuel savings attributable to a wheel alignment checkup program. If alignment checks were added to existing inspection programs, fuel savings would result, but of an unknown amount.

A. Engine Tune Checkup

Because the same engine operating parameters affect both emissions and fuel economy, and because the same laboratory test is used to measure both, EPA's extensive motor vehicle emission surveillance programs provide data that can be used to quantify the fuel savings achievable through more frequent and better engine tune-ups. These surveillance programs have consistently found that the majority of a given year's production of cars or light-duty trucks no longer comply with their design emission standards after two or three years of operation. All of the vehicles in this majority are candidates for corrective engine tune-up maintenance to restore emissions and fuel economy to their proper levels. However, most EPA and other agency studies have focused on a minority of the fleet, typically the 20 to 45 percent of the fleet with the highest tailpipe emissions as measured on an emission short test. Consequently, fuel savings estimates presented here are based on applying fuel economy maintenance to a group of vehicles which is smaller than the group of all vehicles which could conceivably benefit from it. However, since the emission short tests used to select this group tend to select the vehicles most in need of maintenance, the short tests are efficient fuel economy checks as well. Their use is a good way to target maintenance resources to deliver the bulk of the potentially available fuel savings.

Numerous studies 1/ have shown that if an emissions short test is calibrated to select 20 to 45 percent of a fleet of in-use vehicles, and trained mechanics repair the selected vehicles by following manufacturer recommendations, the selected vehicles achieve a three to four percent fuel savings as a result of the maintenance. For the fleet as a whole, the savings average about one percent. This result is as expected. The most commonly encountered forms of improper operation among in-use vehicles, rich carburetor air/fuel mixtures and poor ignition, cause both high emissions and lowered fuel economy. Correcting these problems allows the engine to burn fuel more completely, resulting in greater fuel efficiency. EPA has also found that in-use vehicles which are found to be operating with extremely rich air/fuel mixtures show a larger fuel savings when repaired than do vehicles with only moderately rich mixtures 2/. This again is as expected.

Unfortunately, EPA has also found 1/ that when mechanics employed in commercial repair facilities repair similar in-use vehicles, in the context of an emissions inspection program, there is no net fuel savings, although there are substantial emission reductions 3/. The general explanation is clearly that these field mechanics repair vehicles less completely or in ways other than according to manufacturer recommendations. However, the specific maintenance items which are neglected or done incorrectly have not all been identified as yet. EPA has determined that some mechanics fail to readjust spark timing to the correct setting when they repair a vehicle with misadjusted timing and some mechanics misadjust spark timing on vehicles which were correctly adjusted to begin. These practices appear to account for about one percentage point of the expected-but-not-observed fuel economy savings 4/. In other words, if field mechanics were to change only their methods of deciding when and how to adjust spark timing, they would achieve a one percent fuel savings (combined city and highway driving) from vehicles repaired in the context of an emissions inspection program. This corresponds to about a 0.3 percent fuel savings for the fleet as a whole. Mechanics can be forced to change their spark timing adjustment practices in the desired manner by adding a simple check of the spark timing setting to the existing emission test.

EPA is continuing to isolate other specific maintenance items responsible for the shortfall in fuel savings. Meanwhile, a 0.3 percent savings should be considered immediately achievable. A one percent savings is potentially achievable.

B. Underinflated Tires

The repeated bending of tire material as the tire rolls and each section deforms in turn to conform to the flat road surface consumes energy. The higher the inflation pressure of the tire, the less it deforms, the less energy consumed, and the higher the fuel economy of the vehicles. For typical tires and for the range of inflation pressures found on in-use vehicles, each change of two pounds per square inch (psi) in the tire inflation pressure changes vehicle fuel economy by one percent.

Each vehicle manufacturer recommends tire inflation pressures for each of its vehicle models. These pressures have historically been in the neighborhood of 28 psi. In addition, each tire manufacturer recommends the maximum inflation pressure for its tires. These pressures are generally near 32 psi. Tires may safely be inflated up to the tire manufacturer's recommended maximum inflation pressure, although the "ride" of the vehicle will become less "soft" and road roughness will become more noticeable. Indeed, vehicle manufacturers have recently started recommending pressures which are closer to the maximum pressure for the tires on their new production vehicles.

Tires on in-use vehicles have been surveyed and found to be on average underinflated relative to the vehicle manufacturer's recommendations. The average in-use inflation pressure is about 24 psi. This average underinflation of about four psi is presumedly due to the fact that vehicle owners and servicers do not notice and reinflate a low tire until slow leakage has lowered its pressure considerably. Owners and servicers may also not reinflate to the pressure recommended by the vehicle manufacturer once they do notice a low tire. This latter problem will likely become more common as manufacturers increase their recommended pressures, due to inadequate communication of the change to owners and servicers.

If all tire pressures were increased to and maintained at the vehicle manufacturer's recommended pressure, about 28 psi, the average fuel economy of the vehicles involved would improve two percent. If, as is technically feasible, tire pressures were increased to the tire manufacturer's maximum inflation pressure, about 32 psi, the average fuel economy would improve a total of four percent.

Maintaining a given tire pressure requires periodic checking and reinflation, since slow leaks reduce the pressure gradually over time. The average speed of this pressure loss and the corresponding check interval needed to maintain a desired pressure are not known at present, although field surveillance is in progress to address this question. To achieve the full four percent improvement in fuel economy from the maximum inflation pressure would require that vehicle owners and servicers have easy access to air hoses, be aware of the fuel savings from higher inflation pressures, and check and inflate tires regularly. If all tires on a group of vehicles were checked and inflated to their maximum pressure only once each year as part of an emissions, safety, or special fuel economy inspection program, the fuel savings would be less than four percent. Until reliable data are obtained from the field on the rate of pressure loss, the fuel savings due to an annual inflation to the tire manufacturer's recommended maximum pressure is estimated by EPA to be two percent.

C. Summary of Fuel Conservation Potential

Approximately 20 percent of the national fleet is now subject to annual safety or emissions inspection programs which could be expanded to include fuel economy checks. Of this 20 percent about one-fourth, or 5 percent of the national fleet, is subject to emissions inspection, alone or in combination with a safety inspection. Another 20 percent of the fleet will become subject to emissions inspection programs that will begin by 1983. In 1983, then, about 40 percent of the national fleet could be subject to tire inflation checkups and 25 percent (a subset of the 40 percent) could be subject to engine tune checkups.

With an annual inflation to the tire manufacturer's recommended maximum pressure for all vehicles subject to a safety or emissions inspection program and with special steps to insure proper spark timing maintenance on vehicles already required to be repaired in the context of an emissions inspection program, a fuel savings of 56,000 barrels per day could be achieved. This figure is based on the 25 percent and 40 percent estimates from the previous paragraph, the 0.3 percent and two percent estimates of per-vehicle fuel savings from engine maintenance and tire inflation respectively, and a baseline fuel consumption of 6,400,000 barrels per day for the national car and light-duty truck fleet.

With continous inflation to the maximum pressure and with full engine repairs by trained mechanics according to manufacturers recommended procedures, the fuel savings from the same 40 percent of the fleet could be as high as 118,400 barrels per day.

If all cars and light-duty trucks were covered by a fuel economy checkup program, and not just the 40 percent already subject to a safety or emissions inspection program, the fuel savings could be as high as 320,000 barrels per day under the most favorable case.

Cost to Implement

Tires could be checked and inflated at virtually no additional cost in any safety or emission inspection program, since the time and equipment needed to do so are minimal. The annual cost would be less than fifty cents per vehicle.

The emissions short test used in emissions inspection programs are fuel economy checks for engine tune as well. If the spark timing setting is measured and compared to its recommended value, in order to ensure proper spark timing maintenance, the cost of the inspection will be increased, but not by more than one or two dollars.

If the following assumptions are used:

1. A 16 mpg vehicle

2. An average of 12,000 miles per year

3. Earlier estimates of fuel economy improvements

4. 50¢ per year cost for tire pressure inflation and $1.00 per year cost for spark timing check. (The cost of readjusting the spark timing is not included since the inspection of spark timing would assure that an ignition timing adjustment charge was not levied by the maintenance industry unless it were necessary; in fact, a net cost savings would likely result).

then, the overall "cost" of the fuel saved when conducted in conjunction with an existing emissions or safety inspection program, is 9¢ per gallon. The tire pressure inflation alone "costs" 3.5¢ per gallon of fuel saved, and the spark timing check alone "costs" 42¢ per gallon.

Supply of the New Technology

No new technology is required to perform engine tune and tire inflation checkups. However, new technology is possible which would reduce the time and hence the cost of performing these checks. For example, tire pressure could be measured by squeezing the sidewalls of the tire, rather than by manually attaching a gauge to the tire stem. Tires could be inflated more quickly using electronic control of the compressed air supply, rather than manual or mechanical control. If fuel economy checks were implemented on a wide scale, the resulting market for this type of new technology could hasten its development and application.

Impacts

Because this initiative merely adds fuel economy checkups to existing and planned safety and emissions inspection programs, the impacts on vehicle owners and other program participants are quite minimal.

Owners will not have to submit their vehicles for inspection any more frequently. The time required for a safety inspection would increase by at most two minutes; the time required for an emission inspection by about four minutes. Since tires would be inflated at the time of inspection, owners would not be at all inconvenienced. In the area of corrective engine maintenance, only cars which would require maintenance for high emissions anyway would receive fuel economy maintenance after failing the fuel economy checkup. For about 10 percent of these cars, the type of maintenance and its quality would be forced to change, due to the spark timing check, but there is no evidence that the cost of maintenance would change significantly. Vehicle owners would ultimately pay for the small additional cost of an inspection, unless this were financed from other federal, state, or local revenues.

The U.S. Postal Service began using tire inflation pressures 5 pounds per square inch higher than the vehicle manufacturer recommended pressure in 1974 5/. The Tennessee Valley Authority has inflated tires to the tire manufacturer maximum recommended pressure for many years 6/. The long experience of these two agencies indicates that high inflation pressures do not have any adverse safety impact.

Operators of private garages licensed by states to perform safety or emissions inspections should already have compressed air systems and timing lights, the only equipment needed for the fuel economy checks. Installation of compressed air systems in centralized inspection stations would not be a significant capital expense to any state or city.

Fuel economy checkups would be administratively simple given the existence of a safety or emissions program to which they can be added. In state-operated inspection systems, additional inspectors would likely be needed in small numbers. Otherwise, no new government employees would be needed to implement the checkup program.

If new checkup programs are started for the 60 percent of the fleet not otherwise subject to an inspection program, the impacts on owners, state governments, and the repair industry would be about the same as the impacts being caused by the Congressionally mandated emissions inspection programs which must start operation by 1983.

Implementation Options

Better fuel economy maintenance could be encouraged through consumer information programs or voluntary inspection services, but these implementation approaches are not likely to be as effective as approaches involving regulation. Existing safety and emissions programs already are based on the states' power to prevent noncomplying vehicles from operating on public roads.

The public and repair industry have already been subjected to intensive information programs on the emissions and fuel economy benefits of good engine maintenance. Even so, EPA surveillance programs show that in areas without emission inspection programs, owners and mechanics cause or allow poor engine maintenance. Further consumer information programs are warranted, but should not be considered as substitutes for making fuel economy checks mandatory in jurisdictions which already have mandatory inspection programs of some type.

Better fuel economy maintenance might also result from inservice training programs for engine repair mechanics. In particular, this may be the most effective way to increase the fleet-average fuel savings due to engine maintenance from 0.3 to one percent. Since training is productive only when the recipient is motivated to use the knowledge gained, mechanic training programs are likely to be effective only in the context of a mandatory inspection program.

The question of whether the various state and local agencies responsible for administering existing safety and emissions inspection programs have legal authority for requiring fuel economy checkups has not been investigated. In some states new legislation is no doubt necessary. The question of whether the Federal executive branch has authority to require states to establish fuel economy checkup programs also has not been addressed; EPA, for one, does not have such authority at present. Thus, new Federal legislation may also be necessary.

Recommendations

The U.S. Department of Transportation, which has at least persuasive influence over the state-run vehicle safety inspection programs, should strongly encourage responsible state agencies and state legislatures to include tire inflation checks (including inflation to the recommended maximum tire pressure) as part of safety inspections.

The U.S. Environmental Protection Agency is taking the same action with respect to state-run emissions inspection and maintenance programs. In addition, EPA will verify through demonstration that spark timing checks result in the expected fuel economy savings. EPA will also isolate other ways to achieve fuel savings through emission repairs. As these methods are proven, EPA should encourage states to use them.

A requirement that states with any type of vehicle inspection program include tire inflation checks in those programs should be proposed to Congress.

References

1/ U.S. EPA Office of Mobile Source Air Pollution Control (OMSAPC) Report No. IMS-001/FE-1, and studies referenced therein. Revised June 1979.

2/ EPA OMSAPC Internal Memorandum, "Restorative Maintenance Fuel Economy Analysis," Jim Rutherford to Janet Becker, February 14, 1980.

3/ "Analysis of Oregon's Inspection and Maintenance Program," Janet P. Becker and James A. Rutherford, U.S. EPA, APCA Paper No. 79-7.3, June 25, 1979.

4/ EPA OMSAPC Internal Memorandum, in progress.

5/ Letter, William F. Bolger, Postmaster General, to R.G. Freeman III, Administrator, GSA, February 11, 1980.

6/ Letter, John S. Rozek, TVA, to E. Perley Eaton, Jr., GSA, February 11, 1980.

An Energy Conservation Example Should be Set by the Federal Fleet

Summary

Because the Federal fleet is such a small fraction of the entire national vehicle fleet, the absolute fuel savings from a strong conservation effort for Federal vehicles is not very large. However, strong Federal fleet conservation measures perform two very important functions: 1) they reinforce the public's perception that the Federal government is sincere about conserving energy, and 2) they provide concrete examples of specific conservation measures for the rest of society to consider, and hopefully, emulate. The importance of these functions makes it imperative that the Federal government immediately implement the following conservation measures:

1) Utilization of fuel efficient engine oils in all Federal vehicles.

2) Utilization of low-energy dissipation tires on all Federal vehicles.

3) A more careful and comprehensive fuel economy maintenance program for all Federal vehicles, with particular emphasis on tire pressure, front wheel alignment, and state-of-tune.

4) Consideration of engine cylinder deactivation for all Federal 8-cylinder engines, providing EPA certification is possible.

5) Require every government facility with a travel budget in excess of $150,000 per year to acquire teleconferencing capability.

6) Take forceful action to ensure that government drivers obey the 55 mph speed limit, including the establishment of a toll-free hot-line phone number for citizens to report government violators.

7) The adoption of much more stringent Federal fleet average and minimum fuel economy requirements for new vehicles, with an average of 34 mpg for new vehicles purchased in 1984, increasing to 50 mpg for new vehicles purchased in 1988.

8) An aggressive program to promote the use of methanol fuel in the Federal fleet, requiring that all Federal vehicles purchased in 1986 and beyond be required to have methanol fuel capability.

Introduction

The Federal government vehicle fleet comprises a very small percentage of the national vehicle fleet. The Federal government owns less than one-tenth of one percent of all highway passenger vehicles and approximately one percent of all highway freight vehicles. The corresponding vehicle-miles-traveled figures are of the same magnitude.1/ A first-order approximation indicates that Federal vehicles only consume between 15,000 and 25,000 barrels of fuel daily, a very small fraction of total transportation consumption of almost 10,000,000 barrels of oil per day. Clearly, it would be impossible to achieve major fuel savings by relying exclusively on conservation measures for the Federal vehicle fleet.

But as the other initiatives in this report indicate, a far-reaching transportation conservation program has been proposed which, if fully implemented, would greatly reduce transportation energy consumption. For this program to be successful, every individual vehicle owner and vehicle fleet owner will have to be convinced of the desirability and effectiveness of these proposals. This is where the Federal government's involvement in the program can be most important--by vigorously complying with (and, in certain areas, exceeding) the conservation initiatives it can act as a visible example for the rest of society to emulate. Active Federal transportation energy conservation efforts would also reinforce the necessary belief that the Federal government is serious about the need to conserve energy.

While we strongly encourage the Federal government to immediately begin acting on as many of the proposals as possible, it is clear that, for various reasons, many of the proposals in this report either do not apply to the Federal fleet or could not be successfully implemented on a unilateral basis. The following sections outline those steps which we recommend the Federal government immediately adopt for its vehicle fleet.

Fuel Efficient Engine Oils

More fuel efficient engine oils have been shown to increase passenger vehicle fuel economy by 3 to 5 percent, depending upon the brand of fuel efficient oil, the type of "baseline" oil, and the test procedures utilized to make the comparison. These fuel efficient oils can increase fuel economy in two ways: 1) viscosity reduction, permitting lower viscous drag and pumping losses, and 2) friction modification, reducing the rubbing friction in the oil film between engine surfaces. Though fuel efficient engine oils are more expensive than conventional monograde and multigrade oils, it has been shown that switching to fuel efficient oils is cost-effective at current fuel and oil prices and will likely become more cost-effective in the future. Thus it makes tremendous sense to direct the entire Federal fleet to switch to fuel efficient engine oils immediately.

The problem that Federal fleet operators have with regards to fuel efficient engine oils is similar to the problem of the general public, that is, determining which of the advertised fuel efficient oils are the most fuel efficient. The Environmental Protection Agency, in coordination with the Society of Automotive Engineers and the American Society for Testing and Materials, has developed an engine oils fuel economy test procedure. During 1980, EPA will conduct fuel economy evaluation of several advertised "fuel efficient" engine oils. EPA has also asked the oil companies which have advertised "fuel efficient" engine oils for any supporting fuel economy data. The results of EPA's program and the oil company requests will be made available to the general public as well as to Federal fleet operators. In addition, EPA can provide procurement specifications for government agencies to immediately begin purchasing fuel efficient engine oils. This will allow the Federal fleet to take advantage of fuel efficient engine oils in the very near future.

Besides a fuel economy benefit, many fuel efficient engine oils permit longer oil change intervals, adding to the crude oil conservation effort. Based on the improved fuel economy and longer oil change benefits of fuel efficient engine oils, it is strongly recommended that the Federal fleet switch to fuel efficient engine oils for both light and heavy-duty vehicles.

Low-Energy Dissipation Tires

It is well accepted that radial tire technology improves vehicle fuel economy. It has been determined that, for light-duty vehicles, "average radials" increase vehicle fuel economy by 5 percent over the bias tire baseline case, "best current radials" increase fuel economy by another 3 to 4 percent, and "advanced technology radials" may in the near future increase fuel economy by up to another 6 percent. Thus it may in the near future be possible to realize a fuel economy increase of 14 to 15 percent for light-duty vehicles with advanced technology radials compared to the bias tire baseline case. For heavy-duty vehicles, radials increase fuel economy (again compared to a bias tire baseline) by 4 (urban driving) to 8 (intercity driving) percent and advanced technology tires may soon increase the benefit another 2 to 4 percent. Though the initial purchase price of radial tires is greater than that of bias ply or bias belted tires, the fuel savings and longer tire life expectancy actually makes the utilization of radial tires cost-effective in almost all cases, and their use will likely become even more cost-effective as petroleum prices rise even further. As with fuel efficient oils, it makes tremendous sense to immediately begin requiring all new and replacement tires on Federal vehicles to be radials.

A simple directive requiring all new and replacement tires on Federal vehicles to be radials would be positive, but greater benefits can be gained by determining and requiring the very best radial tires. EPA has recently developed a Tire Energy Dissipation test procedure for light-duty vehicle tires in coordination with the Society of Automotive Engineers and the automotive and tire industries. EPA intends to utilize this test procedure to measure the tire energy dissipation characteristics of over 100 different light-duty vehicle tires. These data will be the first of their kind, and will be made available to the general public and to Federal fleet operators. The above test procedure is adaptable, with minor modifications, to truck tires, and plans to test heavy-duty vehicle tires are also being pursued. The results of these programs will provide Federal fleet operators with all the necessary information to take full advantage of the fuel and cost savings of radial tire technology. In addition, EPA can provide a procurement specification to all government agencies interested in obtaining low-energy dissipation tires.

Fuel Economy Maintenance

Many Federal vehicles on the road today are not performing as well as they could in terms of fuel economy because they are not kept in fuel-efficient operating condition. There are three problem areas in particular in which better maintenance could significantly improve vehicle fuel economy: 1) under-inflated tires, 2) misaligned front wheels, and 3) poor engine tune. Better maintenance in these three areas alone could improve light-duty vehicle fuel economy by 4 to 5 percent.

All of these problems can be corrected through more frequent and accurate maintenance on the part of Federal fleet operators. Under-inflated tires, which are responsible for approximately one-half of the degradation in fuel economy mentioned above, are an especially easy problem to solve. A directive should be issued requiring all Federal fleet tires to be inflated to the maximum recommended pressure which appears on the tire sidewall. An inexpensive tire pressure gauge should be placed in each vehicle, so that the tire pressures can be checked by the driver at any time. The pressures should be checked and recorded every 3 months by the Federal fleet operator. Access to compressed air should be provided at every government facility where vehicles are available.

Surveys of in-use vehicle front wheel alignments indicate that approximately 7 percent of all vehicles are operating with misalignment. Wheel alignment can be checked quickly and cheaply with a scuff gauge device. Scuff gauge devices should be required at every government facility which maintains Federal vehicles, and each vehicle's front alignment should be checked once every 6 months. Any major misalignment should be immediately remedied.

What should be done about the state-of-tune of Federal vehicles is not so clear, since all Federal vehicles are already presumably required to follow a tune-up maintenance schedule. Thought should be given to ways of making the tune-up maintenance procedure more effective.

Engine Cylinder Deactivation

The possibility of retrofitting in-use 8-cylinder engines with permanent or variable cylinder deactivation hardware is discussed elsewhere in this report. Questions remain with respect to the fuel economy improvement and the effect on emissions. We recommend that permanent or variable cylinder deactivation be adopted for all Federal 8-cylinder engines if and when EPA certifies a deactivation system which provides a minimum fuel economy improvement of 10 percent without any deleterious effect on emissions. Should cylinder deactivation prove to be desirable in terms of fuel economy and emissions, Federal action would be a positive example for the general population.

Video-Telephones

It has already been shown that the video-telephone offers a viable alternative for a significant percentage of business-related air travel. Significant energy, monetary, and time savings are available through the increased use of video-telephones. We concur with the National Transportation Policy Study Commission which stated that "the greatest deterrent in institutional use of telecommunications is inertia -- the tendency of a system, such as a corporation, to continue on its present course."2/ Here again, the Federal government can set a much-needed example and simultaneously provide economic stimulation for an (hopefully) expanding market. We recommend that every government facility with a travel budget in excess of $150,000 per year be required to purchase teleconferencing capability with adoption of strict guidelines for its use as a substitute for air travel.

Strict Compliance with the 55 MPH Speed Limit

It has been shown that optimum light-duty vehicle fuel economy occurs at cruise speeds of 30 to 40 mph, and that fuel economy decreases steadily at higher cruise speeds. Furthermore, it has been shown a significant, even a majority, of free-flowing traffic travel occurs at speeds in excess of the maximum speed limit of 55 mph. For example, 74 percent of all vehicle-miles-travelled on U.S. rural interstates in 1977 was travelled in excess of 55 mph, and the average speed of free-flowing vehicles in 1978 was 58.8 mph on rural interstates and 56.7 mph on urban interstates. It has been shown that considerable fuel savings could be achieved if the 55 mph speed limit were strictly obeyed.

There are two convincing reasons why actions must be taken to ensure that drivers of Federal vehicles obey the 55 mph speed limit. One, since the fuel consumed by a Federal vehicle is purchased by the government, the driver of a Federal vehicle lacks the financial motivation to drive slower and conserve fuel that many private drivers already have, and that more and more private drivers will soon have as fuel prices continue to increase. Thus, drivers of Federal vehicles need some additional stimulus to encourage compliance with the speed limit. The second, and even more critical, reason why drivers of Federal vehicles must comply with the 55 mph speed limit is that they act as one of the most visible public symbols of the government's ability to "practice what it preaches" with regards to energy conservation in general and the 55 mph speed limit in particular. With regards to energy conservation, where many improvements depend greatly on individual initiatives and actions, public perception of governmental sincerity is critical. Widespread public recognition that government vehicles were not consistently obeying the 55 mph speed limit could severely weaken the government's speed limit enforcement program as well as other governmental conservation programs.

Actions to better enforce the 55 mph speed limit for Federal drivers must be considered. A toll-free hot-line phone number for citizens to report government vehicles driven in excess of the speed limit should be instituted with managerial responsibility for following-up with Federal employees who are reported to have exceeded the speed limit. The importance of Federal vehicles complying with the 55 mph speed limit cannot be underestimated.

Higher Federal Fleet Average and Minimum Fuel Economy Requirements

The Federal government has already recognized that it should require itself to purchase relatively fuel efficient new vehicles. Executive Order 12003, July 20, 1977, mandated the following Federal fleet average fuel economy objectives (the corporate average fuel economy standards are given for comparison):

Table 1

Corporate and Federal Government Fuel Economy Standards 3/

Fiscal Year	Corporate Average Fuel Economy Standard (mpg)	Federal Fleet Average Fuel Economy (mpg)
1978	18.0	20.0
1979	19.0	22.0
1980	20.0	24.0
1981	22.0	26.0
1982	24.0	28.0
1983	26.0	30.0
1984	27.0	31.0
1985	27.5	31.5

In our opinion, these Federal fleet standards are a step in the right direction, but still inadequate. There are two convincing reasons why much more stringent fuel economy restrictions must and can be placed on the Federal fleet. First, much more stringent standards must be implemented so as to set an example for the general public, to cement the belief that the Federal government believes energy conservation is important and to show that the government is willing to do what it expects the rest of the populace to do. The purchasing and operating of very fuel efficient vehicles, along with strict compliance of the 55 mph speed limit discussed above, are the two most visible actions the Federal government can take to set a good example for the rest of the country. Second, while no survey data is presently available, it is our impression that very, very few Federal vehicle trips involve more than 4 passengers (in fact, likely very few trips involve more than 1 or 2 passengers) and, similarly, that virtually no Federal vehicle trips require any significant amount of cargo space. Thus, a very heavy reliance on fuel efficient 2- and 4-passenger vehicles would involve no sacrifice in terms of limited passenger-carrying ability or flexibility and likely none in terms of "comfort" or "space". Because of these reasons, we believe it is imperative that the Federal government immediately issue much more stringent fuel economy standards for the Federal fleet.

We recommend the following average and minimum (because in the public perception the impression of one "gas guzzler" can negate the impressions of several fuel efficient vehicles) Federal fleet fuel economy standards:

Table 2

Proposed Average and Minimum Federal Fleet Fuel Economy Standards

Fiscal Year	Average Federal Fleet Fuel Economy Standard (mpg)	Minimum Federal Fleet Fuel Economy Standard (mpg)
1984	34	28
1985	38	31
1986	42	34
1987	46	37
1988	50	40

These standards should be immediately implemented via an Executive Order.

Non-Petroleum Based Automotive Fuels

In addition to the aggressive Federal fleet fuel economy standards above, the Federal government should begin to act as a catalyst in promoting the use of non-petroleum based automotive fuels, in particular methanol. Methanol can be readily produced from coal in the near term and from wood products and municipal wastes (or other renewables) in the longer term. The immediate problem with methanol is that its use, either as a pure fuel or in a blend, requires engine modifications. Thus, automotive manufacturers must design new engines which will operate on pure methanol or methanol blends. The most promising near term designs are a direct-injection, stratified-charge engine (Ford's version, now in fleet testing, appears to be closest to commercialization; it is anticipated to be in production by 1984-85) or an engine utilizing dual injection of diesel and methanol fuel. We recommend that the Federal government embark on an aggressive program to purchase methanol-compatible vehicles as soon as they become available, and that all Federal fleet vehicles purchased in 1986 and beyond be required to have methanol fuel capability (either pure methanol or a dual fuel).

References

1/ Transportation Energy Conservation Data Book, Edition 3, D. B. Shonka, et al, ORNL-5493 for DOE, February 1979, pp 1-11 to 1-16. (hereafter "Data Book").

2/ The Impact of Telecommunications on Transportation Demand Through the Year 2000, National Transportation Policy Study Commission, Special Report No. 3, November, 1978.

3/ "Data Book," p. 4-15 (Source: General Services Administration, "Federal Property Management Regulations Temporary Regulation G-32," October 1977.

More Stringent Enforcement of the Corporate Average Fuel Economy Standards

Summary

This initiative closes prototype-to-production shortfalls and test procedure shortfalls, ensuring that Corporate Average Fuel Economy (CAFE) is equivalent to the running of production vehicles at 4,000 odometer miles on a test track, within currently specified environmental constraints. The fuel saving potential of this initiative is as follows, based on implementation in model year 1982:

	Fuel Saved	
	Barrels per day	Cumulative, Barrels
1985	91,000	202,000
1990	170,000	910,000
1995	202,000	1,890,000

The initiative impacts on: 1) EPA, by requiring resources for the improvement of test procedures; 2) the auto industry, by closing test procedure loopholes and making a given fuel economy standard more difficult than they had perhaps been expecting to meet; and 3) the consumer, by making the EPA fuel economy figures more representative and credible.

No additional statutory authority is believed needed to implement this initiative.1/ Promulgation of modifications to existing EPA regulations is all that is required.

Background

In the sense that average road fuel economy is lower than the EPA fuel economy figures, excess fuel is consumed in actual driving. Studies by DOE,2/3/ have indicated that there is indeed a shortfall between EPA and average road fuel economy. EPA4/ has confirmed this, and allocates the causes of this shortfall to a number of factors, including Production Slip and Simulation Variance. "Production Slip" includes all administrative and hardware related factors which can cause differences between EPA mpg figures and those of individual production vehicles, all other variables held constant. "Simulation Variance" refers to mpg differences related to inexact simulation by the EPA tests of items such as road load versus vehicle speed, actual road roughness, non-zero yaw angle aerodynamics, tire/roll versus tire/road interaction, and accurate accounting for vehicle weight.

Fuel Conservation Potential

The fuel conservation potential of reducing EPA-to-road shortfalls is obvious. Fuel economy standards constitute fixed targets for EPA fuel economy, and if Road Shortfalls are diminished, road mpg and actual fuel consumption must improve for a given EPA mpg level.

The magnitude of the reducible shortall for this initiative can be estimated in two ways, as follows.

A. Dynamometer vs. Track Comparisons

Three "dyno vs. track" evaluations conducted by EPA,5/6/7/ showed the following aggregate shortfalls due to simulation variance factors:

Dyno-to-Track mpg Shortfall

	EPA City	EPA Hwy	EPA 55/45	
Bias-Belted Tires	7.4%	9.2%	8.2%	
Radial Tires	4.9%	5.5%	5.2%	
Combined	5.7%	6.6%	6.1%	(70% radial)

Each of the three projects yielded larger shortfalls for non-radial tires than for radials, indicating some malsimulation with respect to tire type for the vehicle models studied.

B. Report to Congress

The "404 Report",8/ shows the following EPA-to-road Shortfalls attributable to production slip and simulation variance, by model year, since 1974:

EPA-to-Road mpg Shortfall

	1974	1975	1976	1977	1978	5-year Average	1979	6-year Average
Production Slip	+0.6%	-6.3%	-9.0%	+1.6%	+2.3%	-2.2%	+1.2%	-1.6%
Simulation Variance	-8.8%	-8.7%	-9.5%	-10.3%	-10.7%	-9.6%	-5.9%	-9.0%
Combined	-8.3%	-14.5%	-17.6%	-8.9%	-8.6%	-11.6%	-4.7%	-10.5%

The specific percentage value chosen for the fuel savings of the initiative is 8 percent. This figure comes from consideration of the nominal 6 percent shortfall seen in both the dyno/track projects and 404 report's 1979 simulation variance, and the nominal 2 percent seen in the 404 report for Production Slip. As noted in the "404 report," actual Production Slip Shortfalls may have exceeded those calculated, making the 8 percent figure, if anything, conservative. Of course, the 8 percent figure does not take credit for test procedure improvements already made, which have reduced simulation variance from a nominal 10 percent, prior to 1979, to the 1979 six percent figure.

The nationwide fuel savings for this 8 percent shortfall reduction are estimated using a fixed fleet size (10^8 cars), a fixed new-car introduction rate (10×10^6 cars/year), a fixed annual VMT rate (10,000 miles), and a 15-year vehicle attrition profile. The fuel economy values employed are:

MPG Values Used in Computation of Fuel Savings

	Standard	EPA mpg	Road mpg Without Initiative	Road mpg With Initiative
1982	24.0	25.5	20.3	21.9
1983	26.0	27.0	21.2	22.9
1984	27.0	27.5	21.5	23.2
1985 and later	27.5	28.0	21.8	23.5

The fuel consumed by 1982 and later models is as follows:

Fuel Consumed by 1982 and later models
(Billion Gallons)

	Without Initiative: For Year	Without Initiative: Cumulative	With Initiative: For Year	With Initiative: Cumulative
1985	18.64	47.16	17.27	44.01
1990	36.13	196.33	33.51	182.32
1995	42.99	401.64	39.88	372.77

It will be noted that a road mpg shortfall is still assumed in the above Figures (e.g. 28.0 EPA vs. 23.5 road). The basic goal of this initiative is to retain test conditions and intent that are consistent with the 1974 model year vehicle test program, using the 1975 modified EPA driving cycles, as believed envisioned by Congress in establishing the CAFE standards, i.e., insure that the EPA to road shortfall does not grow relative to what it was in the baseline model year of 1974 and that percent improvement in fuel economy expected by Congress is achieved. Other causes of shortfall remain, of course, over and above those corrected by this initiative. Included are factors not under the control of EPA, listed in rank order:

Remaining Causes of MPG Shortfall

- Travel Environment, Shortfall equals approximately 9 percent.
- Vehicle Condition, Shortfall equals approximately 5 percent.
- Travel Characteristics, Shortfall equals approximately 2 percent.

Cost to Implement

The cost of this initiative falls on two sectors, EPA and the auto manufacturers. EPA costs will be incurred for test procedure improvement and the promulgation of associated regulations. The EPA costs in terms of personnel and dollars are within resources already being programmed for FY 1981, and hence there is no "added" EPA cost for the initiative.

Net cost to the auto manufacturers is difficult to estimate at this time, but would involve balancing added real costs due specifically to the initiative against cost benefits enjoyed in past model years by the manufacturers due to the regulatory flexibility which would be eliminated by the initiative.

Technology Availability

The initiative does not necessarily require new technology nor a more rapid rate of introduction of planned technology improvements. The initiative will have the effect of lowering EPA mpg values more or less across the manufacturers' model lines, but, since the measure of achievement of the initiative's purpose continues to be the mpg standards' schedule of CAFE values, any manufacturer can accomodate the lowered model mpg's by a modest shift in his model mix.

Impacts

Vehicle pricing may be affected by this initiative, to the extent that manufacturers whose CAFE is near the standards (mainly the domestics) may have to offer dealer and buyer incentives, such as rebates, that are more persuasive than today's incentives, in order to achieve the necessary model mix shift. Buyer disincentives, i.e., increased prices for the lower mpg vehicles will also encourage the purchases of more fuel efficient vehicles.

Implementation Options

Regulatory influence is the only viable strategy for achievement of this initiative as defined.

Recommendation

It is recommended that EPA begin focusing available resources toward developing and evaluating specific, detailed options for achieving the regulatory and test hardware changes needed to accomplish this initiative. This effort should be closely coordinated with effort underway toward improving the overall MPG Information Program, and should be targeted to become effective with the 1982 models, if possible, or no later than model year 1983.

References

1/ Automobile Fuel Economy: EPA Oversight, Hearings before a Subcommittee of the Committee on Government Operations, House of Representatives, Ninty-Sixth Congress, January 29 and February 1, 1980.

2/ McNutt et al, "A Comparison of Fuel Economy Results from EPA Tests and Actual In-Use Experience, 1974-1977 Model Year Cars", SAE Paper 780037, February 1978.

3/ McNutt, Dulla, and McAdams, "Comparison of EPA and In-Use Fuel Economy of 1974-1978 Automobiles, Internal DOE Report, October 1979.

4/ U.S. EPA, "Passenger Car Fuel Economy: EPA and Road - A Report to the Congress", Draft Report, in response to PL 95-619, Title IV, Part 1, Section 404, January 1980.

5/ Austin, "Passenger Car Fuel Economy -- Dynamometer vs. Track vs. Road", report 76-1, Technology Assessment and Evaluation Branch, ECTD, EPA, August 1975. (six 1975 cars, tested in 1975).

6/ Technology Assessment and Evaluation Branch, ECTD, six 1976 cars, tested in 1977 and 1978 (results presented in unpublished draft report).

7/ Standards Development and Support Branch, ECTD, one 1978 car, tested in 1979 (results unpublished).

8/ Op. Cit. (Reference 3/).

More Stringent and/or Restructured Fuel Economy Levels for Automobiles and Light Trucks

Summary

Large savings in petroleum can be forecast, but the savings will not be immediate. This initiative recommends combined Corporate Average Fuel Economy (CAFE) Targets for automobiles and light trucks of 50 mpg in 1990 and 80 mpg in 1995. The targets should be supported with the economic motivation of a fuel inefficiency tax of $100 (1980 dollars) per vehicle produced by a manufacturer who is under the target CAFE, per mpg that the manufacturer is under the target CAFE. (With a target CAFE of 80 mpg, a manufacturer who had a CAFE of 70 mpg would pay a fuel inefficiency tax of $1,000 for each vehicle produced.)

Relative to the current 1985 fuel economy standards, implementation of this initiative would cut automobile and light truck fuel consumption by more than a factor of three. It is projected that this initiative could save about 5 million barrels of petroleum per day by the year 2000.

The major impacts will be felt by the automobile industry in the form of the increased investment needed. It is thus recommended that the U.S. Government set up a guaranteed loan trust fund for the domestic automobile industry during this period of major change. For safety, congestion and other reasons, it is also recommended that the Federal government consider the construction of special roadways for the exclusive use of urban cars (vehicles with curb weights of less than 2,000 pounds), whenever new urban road construction is warranted.

The "cost" of the petroleum saved by the implementation of this initiative approaches $0.00 per gallon. The basic costs will be reduced vehicle performance potential, less vehicle utility, perhaps some loss in ride comfort, and perhaps a negative safety impact - although this is not clear.

All the recommendations of this initiative will require additional Congressional authority.

Background

Cars and trucks account for most of the transportation sector's consumption of petroleum. In fact, cars and trucks currently consume almost 80 percent of transportation petroleum and are the single largest consumers of petroleum in the nation [44 percent of the total according to DOT's Automotive Fuel Economy Program - Fourth Annual Report to Congress January 1980 (draft)]. It is obvious that significant gains in conservation are possible if consumption from cars and trucks can be reduced.

Current programs are in place that are predicted to reduce consumption by cars and trucks. Table 1 shows projected reductions which show up in the year 2000, primarily from conservation efforts (Corporate Average Fuel Economy standards) for automobiles.

A. Current Programs and Standards

Currently, car fuel economy is subject to Corporate Average Fuel Economy (CAFE) standards as follows:

Year	mpg*	Year	mpg*
1978	18.0	1982	24.0
1979	19.0	1983	26.0
1980	20.0	1984	27.0
1981	22.0	1985	27.5

---

* All mile per gallon (mpg) figures presented and discussed herein refer to the EPA composite number as defined in the Energy Policy and Conservation Act.

Light-duty trucks (pickup trucks and vans for the most part) are subject to a complicated matrix of active and proposed standards or ranges of proposed standards as shown in Table 2. As can be seen, the standards for cars are more stringent than those for pickups and vans.

Heavy-duty trucks, the remaining part of the car and truck class, do not have to meet fuel economy standards. There is, however, an Industry/Government Voluntary Truck and Bus Fuel Economy Program.

B. Basis for the Standards.

Congress set fuel economy standards of 20 mpg in 1980 and 27.5 mpg in 1985 for cars, and left it to DOT to set the 1981-1984 standards. DOT set the interim standards as follows: 1981-22 mpg, 1982-24 mpg, 1983-26 mpg, and 1984-27 mpg. DOT's approach to setting the standards for cars was obviously directed by Congress' fixing of the 1980 and 1985 standards. DOT has generally used somewhat conservative assumptions in estimating what standards could be met, including for example, a general assumption that the relative proportions of 4, 5, and 6-passenger cars will remain about the same in the future as it was in the past.

For the light truck standards, with less of a technology forcing mandate from the Congress, DOT has set relatively lenient standards. This is especially the case with respect to the proposed 1982-1985 pickup and van standards. Consider that 1985 cars will have to meet 27.5 mpg while two wheel drive (4x2) pickups and vans will have to meet possibly only 19.7 mpg and 22.4 mpg as a maximum since DOT has proposed a range of standards.

Table 1

Transportation Energy Use, Per Cent

Consumed By	1977	2000
Autos	52.1%	39%
(Light Trucks)	(10.8%)	(11.5%)
All Trucks	25.5%	27%
(Autos Plus All Trucks)	(77.6%)	(66%)
All Others	22.4%	34%
Total	100%	100%

Table 2

Pickup and Van
Fuel Economy Standards

	Light Truck Class		Limited Product Line
Model Year	4 x 2	4 x 4	Light Trucks***
1978	---	---	---
1979	17.2****	15.8****	---
1980	16.0*	14.0*	14.0
1981	16.7*	15.0*	14.5
1982	17.4	15.6	No separate standard
1983**	18.0 to 20.0	15.6 to 18.0	"
1984**	18.8 to 21.4	16.1 to 19.3	"
1985**	19.7 to 22.4	16.2 to 19.9	"

---

* Captive imports must meet standards separately. Other than captives imports must also meet standards separately.

** Proposed.

*** This apparently means International Harvestor.

****No separate standards for captive imports and other 1979 models applied up to 6000 GVW, 1980 and later applies up to 8500 GVW.

Fuel Conservation Potential

More than one approach is considered here. Since all of the approaches involve reducing the fuel consumption of the new vehicle fleet there are several factors, common to all the approaches, which must be considered.

A. New Vehicle Improvements Take Time to Have Their Full Effect Felt

The car and light truck fleet is one that has about a ten percent replacement rate per year. Therefore, even though more than ten million new vehicles are sold every year it takes about ten years for the effect of new vehicles to be reflected in the performance of the vehicles on the road.

B. New Vehicle Improvements Are Expensive

Any cost impact that is multiplied by ten million or so vehicles per year is going to result in large fleet cost numbers. Each $100 cost addition on a single vehicle translates to 1 billion dollars per year on a fleet basis. While it is true that the additional first costs are usually worthwhile, i.e., that the fuel savings pay for the additional costs, it must be kept in mind that making changes to the new vehicle fleet is a process that involves great expenditures of money.

C. Money and Technical Development Control the Rate of Introduction

The ability of the industry to generate the requisite capital to produce the necessary new vehicles/vehicle changes is the most important factor. Also important is the rate at which the research, development, and demonstration (RD&D) process can move. For shorter term, more modest improvements in fuel economy, the capital needs clearly dominate. For longer term, more aggressive fuel economy improvements, the relative importance of both factors tends to equalize.

D. More mpg from Vehicles is Good for the Automobile Industry in the Long Run

The long-term future of the automobile industry is now not as universally bright as it was only a few years ago. As discussed by Brown et. al.1/ the major reasons for the uncertainty are long term fuel availability and price. Any approach that results in improved mpg for vehicles is beneficial to the industry since it essentially stretches the remaining supplies of conventional fuels and provides time to develop alternative sources of fuel, including renewable sources.

E. Value Judgment Areas That Impact Technological Projections of Potentially Achievable mpg Levels

Many assumptions have to be made to make any sort of projection of mpg capability. Unfortunately, some of the assumptions that can impact the projections have either not been made overtly in the past, or have been clouded in "technological" language to an extent that the value judgements that are inherent in the assumptions were never made clear. For future energy conservation policy, some of these areas need to be discussed overtly.

Briefly, these areas are:

1. Performance
2. Size Mix
3. Comfort and Utility

1. Performance

One of the vehicle parameters that influences the mpg that can be obtained from vehicles is acceleration performance. Historically, desired acceleration performance has had a big effect on the nature and characteristics of vehicular powertrains.

Vehicle power demand is often broadly grouped into three areas (1) acceleration power, (2) cruise power, and (3) "hotel load" (auxiliaries and accessories). Considering the last first, hotel loads are typically on the order of 5 hp or so. Cruise power depends on cruise speed, for example, it currently takes 20 to 25 hp to cruise at 55 mph. Adding up hotel load and cruise power only accounts for about 30 hp. Most vehicle engines have much more than 30 hp. This additional hp is there for increased acceleration performance. Any increased hp for acceleration over and above that quoted above also makes higher cruise speeds possible.

Grade requirements also impact hp requirements. Horsepower requirements for grades depend on vehicle weight, speed and grade. For a 5 percent grade, typical of many Interstate highways, and 55 mph, the extra horsepower would be about 22 hp for a 3000 pound car and 11 hp for a 1500 pound car. It can be seen that the grade requirement is about the same as it is for cruising on the level. This implies an approximate doubling of the horsepower requirement for the 5 percent grade. However, grades of 5 percent or more are not too common.2/

Grade, %	% of VMT
less than 0.5	35
0.5 to 1.0	20
1 to 2	15
2 to 3	10
3 to 4	8
4 to 5	6
5 to 6	4
more than 6	2

Doubling the horsepower of engines because six percent of VMT occurs on grades of more than 5 percent may need to be examined further. The grade/speed targets that future vehicles are designed to meet could have a significant impact on their mpg potential.

Now vehicles with only 30 hp would have a good chance to deliver high mpg values, but they would also be in today's value system "poor performers". However, the use of the term "poor performer" emphasizes the point--value judgements that are used to determine "acceptable performance" have a dramatic influence on the size, weight, and mpg capability of a vehicle's engine and any estimate of future mpg capability should state the performance target overtly.

What will be acceptable performance in the future may be much different from what acceptable performance was when gasoline cost 35 cents/gallon and supply was no problem. When one considers \$1.50/gallon, \$2.00/gallon, \$3.00/gallon or even more as the probable future price range and when one considers the possibility of no gasoline at any price due to possible curtailment of foreign supplies, the definition of acceptable performance may well change. The answer to the question "How much more than 30 hp do we need in the future?" must be considered in the light of future price and supply possibilities, as well as the national security implications of the fact that this country now imports over half the petroleum it uses (with most projections showing a still growing proportion of imported petroleum).

As a guide to what the future idea of acceptable performance might be, the Department of Energy (DOE) performance requirements for Electric Vehicles (EV's) were investigated. EVs have been notoriously poor performers and it is estimated that DOE's performance specifications might be a guess at what minimum acceptable performance might be in the future. DOE's current specifications for personal use vehicles are a 0-50 KM/hr acceleration time of between 13.5 and 15 seconds. The 15 second target is an existing one, the 13.5 second target is proposed. When one realizes that 50 KM/hr is only about 30 mph (31.4 mph) it can be seen that these performance targets represent modest performance indeed. In fact, a conventional vehicle with just enough power to cruise at 55 to 60 MPH would probably meet those requirements.

The implications of this reduced acceleration performance capability are not small. It means that the largest engines of the future may need to be no larger than 50 hp or so, quite a change from today's practice, with concomitant benefits in reduced engine weight and reduced friction horsepower.

2. Size Mix

The assumptions about size mix in any future fleet need to be treated. As used here, size mix means the relative proportions of vehicles of different passenger carrying capability in the fleet.

As an example, a fleet with one third in each of the four, five, and six-passenger classes might be abbreviated as 4/33 percent, 5/33 percent, 6/33 percent. In the past, the domestic vehicle industry has been heavily weighted toward the larger size classes.

The average vehicle occupancy in the U.S. is about 2 people per vehicle. This is primarily due to low vehicle occupancy during home-to-work trips. When one considers the future, the concept of the majority of the VMT being consumed by vehicles that could carry 5 or 6 passengers, but which only carry one person most of the time, may require re-examination.

The concept of vehicles which are optimized for the travel mode in which they are used could result in substantial mpg improvements. Implementation of this concept would result in a substantially different vehicle size mix in the future.

First, the home-to-work trip needs to be considered. It is postulated that an optimized 2-passenger "commuter car" would be acceptable for much of the VMT that is consumed in the home-to-work trip sector today. This would be a substantial change from current practice.

Second, the actual people transportation demand has to be analyzed based on past and current data, but more importantly, forecasts need to be made for the future based on demographic and other considerations.

Using information from the Nationwide Personal Transportation Survey (Attachment 1), the average number of occupants by trips can be estimated.

Number of Occupants	Percent of Trips To and From Work	 All Purposes
1	74.5	50.9
1-2	92.1	78.2
1-3	96.2	88.1
1-4	97.8	93.8
1-5	98.8	96.7
1-6	99.2	98.2
All	100.0	100.0

Note that the above implies that the percent of trips made with 5 or more people is 2.2 and 6.2 percent for to-and-from work and all purposes, respectively.

The hypothetical 2-passenger commuter car would suffice for 92.1 percent of all to-and-from work trips, and interestingly, 78.2 percent of all trips for all purposes.

If the purpose of personal transport is to provide trips, the following table indicates what might be an upper bound for a future size mix of vehicles - a fleet which operates at maximum capacity.

Hypothetical Future Size Mix Based on Trip-Occupancy Statistics

Vehicle Size (Number of Passengers)	Percent of The Fleet
2	78%
4	15%
6	5%
More than 6	2%

This would represent a substantial change from current or currently-planned practice. However, since the above hypothetical fleet may be an approximation of a fleet that might just meet trip demand, the question is "How much more size is needed in the future?"

3. Comfort and Utility

The value judgments made regarding acceptable levels of comfort can be generally divided into two classes - climate control and ride. Climate control can be essentially reduced to air conditioning for the purposes of mpg forecasts. Automobile air conditioners, if they were rated in terms of tons of cooling as is done for home air conditioners, would have high capacity — capacities in excess of those required to cool the average home in many cases.3/ Now cars are not larger than homes, so the steady state capacity is based on something else — cooldown rate. Typical performance requirements are based on a Phoenix, Arizona type all-day summer soak (in which vehicle interiors can reach 140°F) and the target is that the vehicle interior should be to a certain tempreature in just a few minutes. This necessitates having a system with a large capacity. The value judgment question here (in addition to the question, "Is air conditioning really necessary?"), is "How cool and how fast should the system be?" It should be noted that were the cooldown requirements to be relaxed, alternative forms of cooling like waste heat driven absorption units (ammonia?) might be more attractive, with a positive mpg influence, since waste heat is used, not an engine-driven compressor.

Ride comfort is part of the performance evaluation of vehicles that involves interior noise, luxury, transmission of road harshness to the passengers, etc. In the past, larger, heavier, more fuel inefficient vehicles have been more comfortable. It is not clear that this is a fundamental consideration, although, for example, the frequency of vehicle ride dynamics is related to wheelbase. Marketing considerations, however, may have also played a large part in the ride/comfort/noise spectrum we see in vehicles today. Since vehicle size and weight (for sound insulation, for example) may be impacted by this, the question that needs to be asked is "What levels of comfort will be acceptable in the future?" (However, while the comfort area may not have dramatic impact on future vehicle mpg capability, it should be considered).

Utility as used here, describes load carrying capability and the ability to perform special power consumptive tasks. For automobiles, utility can be considered as (1) passenger carrying capability, (2) load/luggage carrying capability, and (3) the ability to pull a trailer. Passenger carrying capability has already been discussed. Luggage carrying capability as built in to most vehicles today is typically underutilized or not utilized. The fraction of time or VMT that requires the extra power to pull a trailer is very small. Vehicles could have higher mpg capability, if infrequently used capacity was a smaller consideration in the optimization process.

For the future, it may well be that potential (unused or underused) utility will be seen as mpg disutility.

The consequences of "potential utility" are readily apparent in the current fleet of light-duty trucks (pickups and vans). This large in number and large in fuel consumption, part of the vehicle fleet is carrying around unused capacity for most of their operation. As an example of this potential utility, consider the case of the EPA light-truck emission regulations for model year 1979. Because it was assumed that the extra utility of pickups and vans was actually used a significant part of the time, EPA proposed to define the test weight of these vehicles as curb weight plus 500 pounds. The 500 pounds accounts for occupants and a light load. (The corresponding number for cars is 300 pounds.) The assumption that trucks carry more load than cars could not be substantiated, and based on the comments received the definition of test weight for trucks was made the same as for cars.

If a vehicle is designed to carry a heavy or bulky load, the vehicle will be heavier, bulkier and have a larger engine than it may need for the time the potential utility is not being used.

In terms of their use, pickups and vans are personal transportation vehicles nearly all of the time. The mpg disutility of the unused capacity is partially why current trucks get poorer mpg than cars do and the assumption that the past and future mpg disutility of pickups and vans will continue into the future is at least part of the reason why DOT is proposing mpg levels for pickups and vans that are as much as 7 or 8 mpg below those for cars for 1985.

Mpg disutility limits the mpg capability of pickups and vans. For the future, example value judgment questions for these types of vehicles are: "How much load carrying capacity is really needed?" and "Should the design of all the vehicles be dictated by the ability to carry (sometimes? maybe?) 4' x 8' sheets of plywood flat between the wheelwells, or x number of bales of hay or 5 refrigerators or whatever?"

In the high fuel price, limited fuel availability future that we face, the disutility of carrying around unused capacity may have to be considered carefully in comparison to other options which may be more fuel efficient on an overall basis, i.e., most vehicles optimized for their average loads, and the demand for the infrequent, very-heavy or bulky loads being met by rental vehicles.

A parallel discussion to the load/volume utility could be made for four-wheel drive vehicles. In the future it may be pertinent to ask to what degree the mpg capability of vehicles needs to be limited by the constraints of four-wheel drive.

F. Degree of Technological Availability

This is another wide-ranging part of any improved fuel efficiency study. There are several technical areas in which vehicle fuel efficiency can be improved, i.e. engine/drivetrain, vehicle structure, rolling resistance, aerodynamic drag, etc. However, there is not one unique single list of values of the fuel economy improvements that can be associated with each area of improvement. Rather, there is a spectrum of fuel economy improvements that can be associated with each area. The spectrum starts from little or no improvement, all the way to the maximum that is theoretically possible. Now over the range of the potential improvements, there are two basic considerations that must be examined.

First, for every improvement area there is and will continue to be apparent and real controversy over the maximum theoretical improvements that can be made. The apparent controversies can arise from different assumptions made about certain value judgment limits of some parameters. These value judgments were discussed earlier. Real controversy can arise when one is estimating the theoretical bounds of any parameter due to the vagaries of mathematical models and predictions of what component efficiencies might be attainable at what point in time, for example.

Second, there is a tendency in the engineering community to be conservative in estimating the values of achievable future benefits. This tends to obscure the limits of improvements somewhat. In some cases the limits of improvements may be set by a combination of factors such as conservatism, desire to avoid controversy, consensus and/or a least common denominator.

There could be a great number of possible future cases that could be studied with respect to this subject. However, that is not done here. What we have done is attempt to evaluate an upper bound (or range of upper bounds) for future fleet mpg. The bottom of the range is reasonably well known. The standards for 1985 are 27.5 mpg and the post-1985 mpg possibilities that DOT is considering appear to be in the low to mid 30's.

In looking for a range of upper bounds we will make the value judgment based assumptions that tend to imply the highest mpg capability. For example, the upper limit assumptions are:

1. Performance - Just enough to cruise at a speed about 55 mph with some reserve for hills and hotel load. This means 50 hp or less for nearly all cars.

2. Size Mix - The "minimalist" size mix discussed earlier: 78 percent 2-passenger, 15 percent 4-passenger, 5 percent 6-passenger and 2 percent more than 6-passenger vehicles.

3. Utility and Comfort - Utility - light trucks treated the same as cars; it is assumed that utility when needed can be rented, and that true work vehicles will be classified as heavy-duty. Comfort - the best that can be managed with the vehicle size and weight optimized for fuel economy.

4. Degree of Technological Availability - Assumptions that are not necessarily conservative.

Discussion of the possible future technical improvements are separated into three areas: body structure, movement resistance, and powertrain. Much of this discussion and the conclusions in the area of potential technical improvements are similar to those of the Report by the Federal Task Force on Motor Vehicle Goals Beyond 1980.4/ Specific references are limited to areas where examples might be useful.

1. Body Structure

The body of a vehicle plays a great part in mpg because it is the major part of the vehicle's weight, and weight has a strong influence on fuel economy. Current domestic designs appear to be moving toward more weight and space efficient designs that were and are exemplified by European practice. Limited material substitution is also taking place. At the other end of the spectrum, however, are body designs based on different materials that offer substantial weight savings. Over a year ago a six-passenger vehicle was exhibited at the annual SAE meeting that was constructed to a very large extent with composite materials. This vehicle in its conventional configuration was a 4000/5000 pound car. Constructed from the composite material, its weight was reported to be 2500 pounds. This represents approximately a 40 percent reduction in weight with no change in utility. Other materials that are receiving attention are foam-filled, metal-skinned structures which offer light weight and some potentially attractive crash properties, and plastics in vehicle structures.5/

The weight reduction spectrum for the future can be seen to range from zero to something which might approach 40 percent or so.

2. Movement Resistance

Movement resistance primarily involves aerodynamic drag and tire rolling resistance. With respect to aerodynamic drag the important parameter is the product of the drag coefficient and the frontal area. Since frontal area is determined to a large degree by passenger carrying capacity, the drag coefficient is the parameter of major interest. Current vehicles tend to be in the 0.4 to 0.5 range. This represents somewhat of an improvement over past practice of drag coefficients in the 0.5's. Some vehicles have been claimed to be in the mid 0.3 range. Recent research reported from Europe indicates that values in the low 0.2 range may be achievable6/, with the caveats that when the design gets "productionized" the drag coefficient may get somewhat larger. The appearance of such low drag vehicles is somewhat unusual looking - looking somewhat like a "cucumber on wheels." This surfaces another value-judgment factor not discussed previously, i.e., the looks or the styling of vehicles. Future low drag vehicles will not necessarily look sleek. In addition, the looks may be somewhat different for the different vehicle size classes.

With respect to tires, the first generation radial tires have been able to reduce tire rolling resistance substantially. However, tire technology has advanced, and tire rolling resistance has been reduced to half of what it was not long ago, with more improvements expected.

It would appear that the power required to operate future vehicles at a steady state cruise speed might well be reduced by a factor of 2 since both drag coefficient and rolling resistance could be reduced by about the same factor.

3. Powertrain

Based on the above discussion and assumptions, future vehicles could be ones with engines that are small compared to current practice. The engines could be small in displacement with large cylinders, and operated at low speed. Such engines could have attractive (low) friction horsepower characteristics. Probably engines of 2, 3, and 4-cylinders would comprise the range of engine sizes.

What kind of engines? For the small (some would say tiny) engines we are discussing here, there are really only two practicable choices for the future: gasoline engines (Otto cycle and direct injection) and diesel engines.* Considering gasoline engines and in keeping with the extrapolative nature of this study, we will only consider stratified charge engines of the Ford programed combustion (PROCO) type, although others like Texaco Controlled Combustion System (TCCS), Maschinenfabrik Augsburg-Nuernburg AG (MAN), etc. are worth considering in a more detailed study. The MAN system, for example, has been run at Ricardo on approximately 90 octane gasoline with a 13 to 1 compression ratio. This shows the benefits of the mechanical octane, with the fuel economy characteristic of the diesel.

---

* Electric vehicles are discussed in Attachment II.

The PROCO engine is a direct-injection, gasoline-fueled, stratified-charge engine. Ford has claimed 20 percent improvement in fuel economy over conventional gasoline engines with this concept. The PROCO has good mechanical octane capability and can be considered to have relatively wide fuel tolerance for a gasoline engine - nearly a multifuel engine, although not an omnifuel engine like the TCCS engine.

The PROCO has unfortunately not yet been demonstrated in the small size engines. Much work was done at 400 CID and 351 CID, and current packages are said to be 302 CID (5 liters). The specific power is not known but with cylinders of about 625cc the power should be between 20 and 30 Bhp/liter. If the cylinder sizes can be kept about the same there is every reason to believe that the engine will scale down. It is not known if the cylinders can be reduced to 350 to 400cc/cylinder or not.

Small diesels of the 4-cylinder type have been made with divided combustion chambers. Typically these engines are 350 to 400cc/cylinder and have 20 to 30 Bhp/liter. Current diesel technology in the VW Rabbit (a 4-passenger car) gives about 45 mpg. VW has also investigated turbocharged 4-cylinder diesels with better mpg - above 50 mpg. More recent developments include a prototype 4-passenger vehicle said to be a 3-cylinder, 1.2 liter diesel with some form of supercharger and with a system which shuts off the engine automatically at idle. Such a vehicle has been claimed to have 70 + mpg potential.16/ Even if this 3-cylinder diesel is installed in the Polo, a slightly smaller vehicle than the Rabbit, it would still be a 4-passenger vehicle for the purposes of this study. If 30 Bhp/liter can be obtained from VW's new 3-cylinder engine, at 36 Bhp it might be one of the more powerful of the future engines.

In comparing the PROCO and the diesel in terms of fuel economy potential, over the conventional gasoline engine, the engines actually aren't too different, if one takes GM's claim (25 percent better at constant performance) and Ford's claim (20 percent better).

The mpg values quoted for the VW prototypes are based on demonstrated data, so any extrapolation to the lower power, even lighter weight vehicles should not be technologically risky. In addition, the VW technology is certainly not the far end of the spectrum as far as diesel fuel conservation technology is concerned, so there is room for even further benefits. However, no further projections were made because the policy-related mpg issues (value judgements) will have more impact than further engine efficiency improvements, and also because there isn't much data on one or two-cylinder diesels or PROCOs.

Transmissions are an important part of the drivetrain. Multispeed torque converters with lockup and manual transmissions dominate now. At the other end of the spectrum, continuously variable transmissions (CVTs) have always been considered as attractive mpg improvers since they allow more optimum operation within the engine map. The CVT has been pushed in the past by single-shaft gas turbine proponents, but it appears that the first practical one for cars will come from the Van Doorne's Transmissie/Borg-Warner/Fiat work, and will be for conventional engines. CVTs of this type are attractive since they are automatic transmissions (no retraining of the driving public needed) and also because one of their major deficiencies in the past was that they were power limited. With the engine sizes considered here, that problem vanishes.7/

G. Putting it All Together

Given the above discussion, it is possible to project future fleet mpg values in the range of 70 to 100+ mpg. Whether these are actually achieved will depend to a great degree on what kind of future vehicle fleet is wanted. Such a fleet may be attractive in terms of preserving personal mobility.

Table 3 shows the actual 1978 sales, the manufacturer projected sales for the 1980 model year and the actual sales for the first three months of 1980, for the three basic vehicle categories being considered herein (2-passenger vehicles, 4-passenger vehicles, and 5/6-passenger vehicles and light trucks). It is clear from Table 3 that consumer choice has shifted dramatically in a very short period of time.

Table 4 shows the highest and average mpg, the lowest and average test weight and the lowest total road load at 55 mph for each vehicle class for 1980 model year vehicles. Using the first quarter 1980 actual sales, we can compute Industry Average Fuel Economy (IAFE). The IAFE based on Average Class mpg is 21.4, based on Best Class mpg is 36.6 and based on Best Class mpg excluding trucks is 37.7.

The projection of the effects of the technological improvements discussed previously along with assumptions about further consumer choice shifting can lead to a wide range in future fleet mpg. Table 5 contains the basic information for the development of many possibilities. The vehicle weights and total horsepower requirements to cruise at 55 mph are divided into the lowest class value now, today's technology and advanced technology (or push technology) for each basic vehicle class. The today's technology vehicle weights are essentially the lowest class values in production now (except, of course, for the 2-passenger vehicles). The push technology weights are today's weights reduced by 30 percent. (The previous section projected weight reductions up to about 40 percent as maybe being possible/practical.)

Table 3

1978 vs. 1980

Vehicle Class (Cars Only)	1978 Actual Sales	1980 Projected Sales	3 months, 1980 Actual Sales
2-passenger*	1.7%	2.0%	~ 2.0%
4-passenger	29.4%	36.7%	44.0%
5/6-passenger	68.9%	61.3%	54.0%
(Includes light trucks)			
2-passenger*	1.3%	1.6%	~ 1.6%
4-passenger	22.3%	28.8%	35.4%
5/6-passenger and light trucks	76.4%	69.7%	63.0%

---

* Dominated now by the Corvette.

Table 4

Current Passenger Vehicle Characteristics

Vehicle Class	Test Weight [2]		Lowest Total Road Load at 55 mph [3]	mpg		Sales Mix [4]
	Lowest	Average		Highest	Average	
2-passenger [1]	2250	2900	14.8	30.4	21.6	1.6%
4-passenger	2000	2700	11.9	47.4	26.6	35.4%
5/6-passenger and light trucks	2500	3800	12.3	32.6	19.3	63.0%
						IAFE [5] = 21.4 (Based on Average Class mpg)
						IAFE = 36.6 (Based on Best Class mpg)
						IAFE = 37.7 (Based on Best Class mpg excluding light trucks)

---

[1] Limited models, Fiat X1/9 mpg and weight, Corvette road load.
[2] Curb weight plus 300 lbs.
[3] Average road load not readily available, but there is currently only modest variation.
[4] Actual sales for first three months of 1980.
[5] Industry average fuel economy.

Table 5

Future Fleet Possibilities

Vehicle Class	Vehicle Test Weight, lb[1]	Cruise 55 mph, hp[1]	Extra hp required to maintain 55 mph up a 5% grade	Accessory Load, hp	Utility Factor, hp[4]
2-passenger[2]	2250/1500/1050	14.8 / 9 /7.2	-/11 /7.7	3	0
4-passenger	2000/2000/1400	13.0[3]/9.8 /7.8	-/14.7/10.3	4	5
5/6-passenger and light truck	2500/2500/1750	13.5[3]/10.1/8.1	-/18.3/12.8	5	10

Vehicle Class	Acceleration Power, hp[5]	Average Engine Size Needed[6]		Projected mpg	Vehicle Mix, %			
		hp	Cylinders		Today	Mix 1	Mix 2	Mix 3
2-passenger[2]	-/16.9/12.2	-/23 /18	-/2/2	-/110/140	1.6	20	47	78
4-passenger	-/21.4/15.4	-/33.5/27.1	-/3/3	-/78 /93	35.4	50	35	15
5/6-passenger and light truck	-/25.9/18.6	-/43.4/35.9	-/4/3	-/58 /70	63.0	30	18	7

---

[1] Lowest Class Value Now/Today's Technology/Push Technology (or Advanced Technology).

[2] Dominated now by the Corvette.

[3] Second lowest, several vehicles exhibited similar results.

[4] For trailer towing and hauling of goods; for the 5/6-passenger and light truck class, 30 hp per vehicle for utility - but assuming only 1/3 of the vehicles elect this utility; for the 4-passenger class, 20 hp per vehicle for utility use - but assuming 1/4 of the vehicles elect this utility; and for the 2-passenger class, no utility power assumed.

[5] Sufficient to accelerate from 0 to 50 mph in 20 seconds, includes power needed to accelerate the vehicle mass and to overcome frictional resistance (assumed 0.4 of total 55 mph road load), and assumes maximum power continuously available (CVT with 90 percent efficiency).

[6] Cruise plus grade plus accessories plus utility - generally acceleration is not limiting.

At 55 mph, aerodynamic load on the vehicle is about 50 percent of the total opposing force, tire energy dissipation is about 30 percent, and drivetrain losses are about 20 percent. The today's technology 55 mph cruise requirements reflect only a 50 percent reduction in the rolling resistance and drivetrain losses. The push technology requirements represent an additional 30 percent reduction in aerodynamic drag. (The previous section projected overall cruise power reductions of about 50 percent.)

Performance sufficient to maintain 55 mph cruise on a 5 percent grade was assumed. The accessory loads are believed to be sufficient. The assumptions for the utility factor are given on Table 5; however, light trucks were treated basically as cars with an assumed utility need being provided primarily through rental mechanisms with the light truck category showing up as a small part of the third vehicle class.

The acceleration power represents a theoretical possibility for performance in accelerating from 0 to 50 mph in 20 seconds (zero grade). A continuously variable transmission would be necessary to allow these power levels to provide the desired acceleration (90 percent efficiency assumed). However, at this acceleration performance specification, the other performance requirements are limiting and control the engine size needed as indicated in Table 5. Therefore, on the average, acceleration performance would be better than 0 to 50 mph in 20 seconds.

The projected mpg values assumed the efficiencies that can be provided by PROCO or diesel engines. The size mix assumptions vary from what is considered a very modest size mix shift (Mix 1), to a mix (Mix 2) which assumes that urban cars will only be used in urban areas in relation to the trip needs, e.g., 60 percent of miles traveled are in urban areas with 78 percent of all trips involving 1 or 2 people, and finally to the "minimalist size mix" (Mix 3) as discussed earlier. The minimalist size mix is presented to give a feel for the limit of possible fuel conservation through mix shifting. (However, if we extrapolated the recent size mix changes which have occurred due to consumer choice, the minimalist size mix would become limiting even sooner than 1990.)

Several CAFE cases can be derived from Table 5. Table 6 presents six such cases. Perhaps case II is the optimum from a cost and public acceptance standpoint. However, from an aggressive energy conservation, public acceptance balance, Case V may be the preferred option.

The dominant influences in this analysis are, of course, the performance capacity reductions, the engine technology assumptions, the vehicle weight reductions, and the vehicle size mix changes. The performance capacity reductions would perhaps be the easiest to accept since 0 to 50 mph acceleration would still be less than 20 seconds. The engine technology and transmission assumptions are based on PROCO or diesel engines, fully optimized,

Table 6

CAFE Options

		CAFE
Case I -	Today's Technology with a Modest Size-Mix Shift (20 Percent Urban Vehicles) - Mix 1	75 mpg
Case II-	Today's Technology with a "Use Urban Cars for Only Those Urban Trips Which Involve 1 or 2 People" Size-Mix (47 Percent Urban Vehicles) - Mix 2	84 mpg
Case III-	Today's Technology with a "Minimalist" Size Mix (78 Percent Urban Vehicles) - Mix 3	98 mpg
Case IV-	Advanced Technology with Mix 1	90 mpg
Case V -	Advanced Technology with Mix 2	103 mpg
Case VI-	Advanced Technology with Mix 3	122 mpg

and continuously variable transmissions. Specifically, it was assumed that a vehicle requiring 36 Bhp could produce an EPA composite fuel economy value of 70 mpg. Extrapolation to higher and lower horsepower requirements was simply ratioed. The vehicle weight reductions for the advanced technology case will be difficult and costly, but the best of today's technology can provide very impressive fuel savings. Perhaps the vehicle size mix changes raise the more difficult questions, as the possibility of such a change is not technologically limited, but rather societal-choice limited. As was discussed earlier, such mix changes would more closely represent usage patterns for personal transportation. Indeed, mix changes could be a large benefit to the automotive industry. Such a strategy would likely encourage households to have several vehicles each with a different functional design. Perhaps the most common situation would be a household with three vehicles; two being 2-passenger urban vehicles and the other vehicle either being a 4-passenger or 6-passenger family vehicle for long trips, etc. Such a strategy would not be inconsistent with current vehicle household ownership trends either. In 1974, the household ownership of motor vehicles was as follows: 83.8 percent of the households had one or more vehicles, 45.1 percent of the households had two or more vehicles, and 10.2 percent had three or more vehicles. The percentages have surely shifted even further in the last 6 years and by 1995 would easily be compatible with the urban vehicle strategy.

Relative to the current (1985) fuel economy standards, a CAFE of 80 to 90 mpg would cut automobile and light truck fuel consumption by more than a factor of three. Assuming that in the year 2000, automobiles and light trucks consume 7.6 million barrels of petroleum per day, then a CAFE of 80 mpg would save approximately 5 million barrels of petroleum per day.

Cost to Implement

No new technology breakthroughs are required to implement this initiative, just basic value judgment changes. The American public must be willing to accept energy conservation over performance potential, and a more energy-efficient vehicle mix over the continued operation of vehicles with unused utility.

The result of the implementation of this initiative would be a different automobile industry product--the evolution toward a much more fuel-efficient fleet. The industry would have to introduce radically new/different vehicles, but a decision now to achieve that goal would allow giant steps to be taken instead of the small steps now being taken in the auto industry--the small-increment-by-small-increment "downsizing" of the conventional car. The redesign (downsizing) of an existing "large" car for a 5-year production run to hang-on to a rapidly dwindling market is extremely costly, as compared to the 1-step introduction of a new car. Over a reasonable period, 10 to 15 years, with government guaranteed loans if needed,* the industry could make the necessary changes and be profitable. A rough estimate of the new capital necessary is 60 billion dollars. Other estimates range from 50 to 75 billion (1979-80) dollars.8/9/10/ Why will it cost so much? The domestic automobile industry is a matured industry, with many of its production facilities quite old (50 to 60 years old). The types of vehicle changes needed, driven by the need for more fuel-efficient vehicles, require substantial modification to production facilities and, thereby, offer an opportunity to completely remodel existing factories or build entirely new facilities. However, the potential for increased efficiency (improved productivity) comes with new facilities. U.S. domestic automobile producers have for some time been at a disadvantage relative to many of their foreign competitors, especially in the area of modern, efficient production facilities. (Many of the foreign manufacturers had to re-build production facilities after World War II, and thus are generally newer than domestic production facilities). Another consideration in this regard is that some portion of these capital needs exist anyway. Production tooling wears out and must be replaced, new engine lines (transmission lines, etc.) are introduced, and during a 10-15 year period some facilities would have required replacement simply due to obsolescence. But if the industry continues the small-increment-by-small-increment "downsizing" process to achieve the 1985 CAFE standards and then continues that process to achieve the potential of this initiative (i.e., repeats the "downsizing" process again), then the cost could be well over $150 billion (1980 dollars).

Business Week 6/ in discussing the domestic automobile industry's reluctance to simply abandon its full-size and intermediate cars and the associated risk had this to say:

> "This heightened risk has not been lost on the government. The Transportation Dept., for example, has delayed proposing fuel economy standards for cars built after 1985. Says Transportation Secretary Goldschmidt: 'We will not make a move until we have a lot better feel for the difficulties and problems of the industry.' The hitch, says Goldschmidt, is that in the past it could make huge investments - in engines, for example - and expect to get a return on that capital for as long as 20 years. Now, he says, 'they are confronted with the prospect that today's entire retooling effort might have to be done again in some significant fashion after 1985.'
>
> Whether the market or the government demands it, that would be a horrifying prospect for Detroit. But if the industry must lay out $75 billion in new investment between now and 1985 only to be forced to do it again, it will have only itself to blame. It shortsightedly tried to prop up the big car, a dinosaur that relied on cheap energy. Cheap energy is now gone for good, and with it the big car."

---

* Alternate funding approaches could also be considered.

The one thing the U.S. automobile industry doesn't need now is uncertainty about the type of cars it should be planning to build for the future. Implementation of this initiative will provide the needed certainty about future fleet requirements, will allow the industry to take the more efficient one-step processes of introducing new cars, will provide the opportunity for improved productivity, and will produce new cars that should compete well in the future world market.

Even if it is assumed that capital requirements will total $100 billion (1980 dollars) between 1985 and 1995, and with the assumptions that the new production facilities are productive for 20 years and 10 million vehicles per year are produced, then the average capital write-off per vehicle is about $500 (1980 dollars) (assuming inflation equals interest for a first order approximation, which is a reasonable possibility assuming government loans). Of course, just to continue to produce cars on a business-as-usual basis requires the write-off of capital because production tooling wears out and is changed for other reasons (such as for styling changes). Therefore, much of the capital write-off expected as a result of major production facility modernization would have been required anyway and with the expected increased productivity of the new facilities, the real additional capital write-off will be small indeed. The problem is mainly one of capital availability to the industry.

It is not anticipated that additional government implementation or R & D costs would be needed.

The consumer will receive large life-cycle savings, due primarily to the fuel savings. For example, when the life-cycle fuel consumption of a 27.5 mpg vehicle is compared to an 80 mpg vehicle, the 80 mpg vehicle would save about 2,400 gallons of fuel. If it were assumed that the cost of fuel in 1995 is $3.00 per gallon (1980 dollars), the life-cycle savings of the 80 mpg vehicle would be $7,200 (1980 dollars). The additional cost of vehicles under the "push technology" option (30 percent weight reduction and 30 percent reduction in aerodynamic drag) is truly speculative, however, a rough estimate might be $1,000 (1980 dollars), still a good buy. The cost of vehicles under the "current best technology" options is not expected to increase; indeed, as compared to the average 1980 car (in 1980 dollars), such vehicles on the average should cost substantially less - much as today's "fuel-efficient" four-passenger vehicles cost less than the average "full-size" four-passenger vehicles. However, individuals will still retain the freedom of choice for larger, heavier, more powerful vehicles - if they want to pay the price. Such vehicles will not only cost the manufacturer more to build, but, depending on the relative demand among the basic vehicle categories, the manufacturer may have to pass through the fuel-inefficiency penalty (whether it is a civil fine, as exists now, or a tax/fee) to discourage too much demand for such vehicles. (This is discussed further in the Implementation Options section.)

The "cost" of the petroleum saved by the implementation of this initiative approaches $0.00 per gallon. The basic costs will be reduced vehicle performance potential, less vehicle utility, perhaps some loss in ride comfort, and perhaps a negative safety impact - although this is not clear.

One final point regarding costs - the cost of not implementing this initiative is great. Consider that the U.S. will spend 90-95 billion dollars in 1980 for imported petroleum (a cost that is increasing dramatically each year), perhaps 15-20 billion dollars in 1980 in imported automobiles (Figure 1 shows how imports have steadily been increasing their share of the U.S. market), money for imported vehicle parts, lost U.S. auto industry jobs, unemployment compensation, inflation, etc. If need be, a far lesser price would be to Federally subsidize the rebuilding of the U.S. Auto Industry, or at a minimum, guaranteed loans.

Supply

Considering a 10- to 15-year implementation period, the industry should have no problem in supplying the new vehicles needed as a result of this initiative, provided sufficient capital is available.

Impacts

The largest economic impact expected is that on the automobile industry. The need for capital in order to achieve the goals of this initiative is great. (See the section, Cost to Implement, for more detailed discussion.)

Since a major aspect of this initative would be the reduction in weight of the automotive fleet, the U.S. steel industry would likely be negatively affected. However, as will be discussed later in this section, new demands for steel may result from implementing this initiative.

The use of vehicles which are more suited for the purpose of a given trip may be viewed by some as a lifestyle impact. However, it is possible that a vehicle mix shift to more personalized vehicles could be characterized as a positive lifestyle impact. Certainly, the retention of personalized mobility would be viewed by many as a less significant lifestyle impact than a massive shifting to various mass transportation systems.

The concern of a negative safety impact due to the widespread use of small, light vehicles may have merit.11/12/ As can be seen on Figure 2 (from reference 11) special consideration must be given to the assurance of adequate safety with the widespread use of small cars. Passive restraints and improved sidecrash protection should probably be viewed as a necessity. However, the potential alarm generated from viewing Figure 2 should probably be conditioned by the fact that during the period represented by the

Figure 1

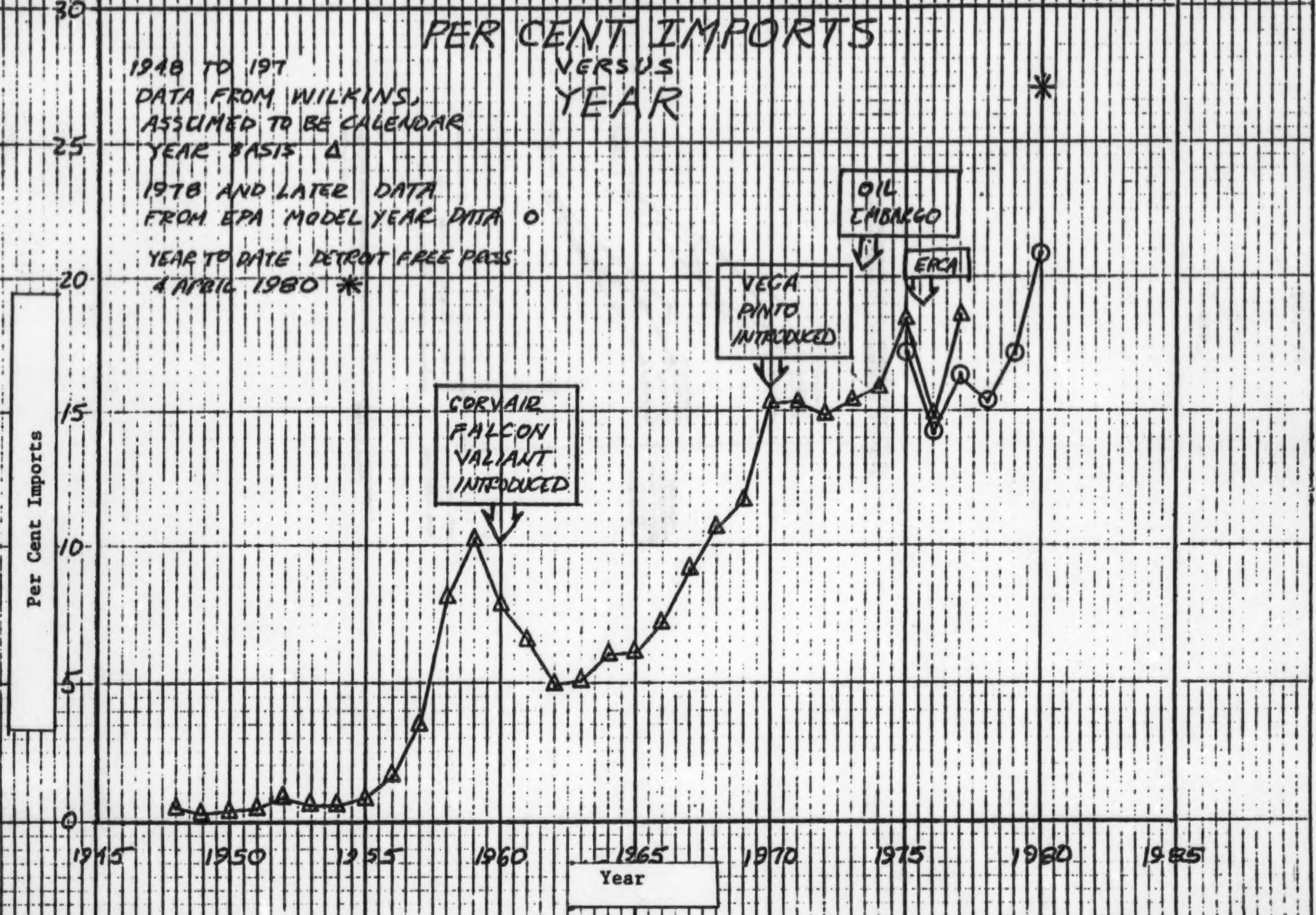
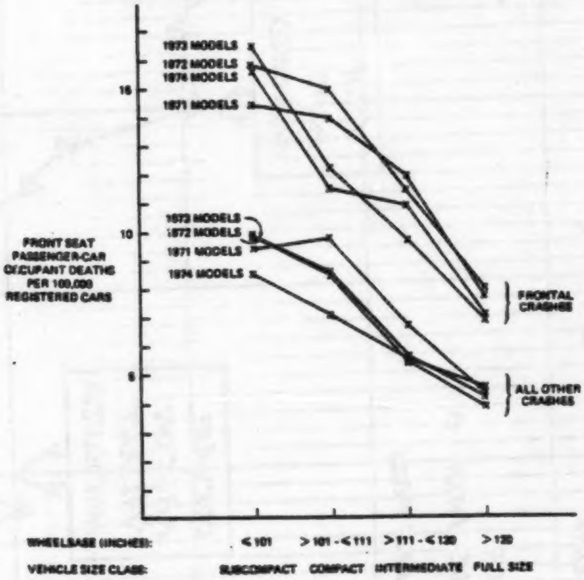

PER CENT IMPORTS
VERSUS
YEAR
1948 TO 197
DATA FROM WILKINS,
ASSUMED TO BE CALENDAR
YEAR BASIS Δ
1978 AND LATER DATA
FROM EPA MODEL YEAR DATA ○
YEAR TO DATE DETROIT FREE PRESS
4 APRIL 1980 *
CORVAIR
FALCON
VALIANT
INTRODUCED
VEGA
PINTO
INTRODUCED
OIL
EMBARGO
ERCA
Per Cent Imports
0
5
10
15
20
25
30
Year
1945
1950
1955
1960
1965
1970
1975
1980
1985

Figure 2

U.S. FRONT SEAT PASSENGER-CAR OCCUPANT DEATH RATES BY CAR SIZE – 1971-74 MODELS IN CALENDAR YEAR 1975[1]



[1] SOURCE: NHTSA FATAL ACCIDENT REPORTING SYSTEM AND R. L. POLK NATIONAL VEHICLE POPULATION PROFILE, JULY 1 1975.

IIHS, April 1977

statistics on Figure 2, the percentage of small cars on the road was small compared to what it would be under this initiative, that is, all the cars will become smaller and lighter in the future. And to some extent, the crashing of a small car with a large car (or truck) may have accounted for the higher death rates in the small cars as compared to the large cars, rather than any inherently poorer barrier crash protection capability of the small car versus the large car. Another consideration is that during this period, smaller cars were likely driven to a larger extent by younger drivers who traditionally are involved in more fatal accidents. In addition, it is important to note that even the "push technology" option represents only modest additional reductions in vehicle weight, as compared to some of the most popular cars now being sold. Still another important point is that the 2-passenger urban cars will likely be used principally in urban areas where urban cars will dominate (i.e., less likely to have a small-to-large vehicle crash), and average speed will be less (average non-urban speed is about 50 mph whereas average urban speed is about 20 mph).

The issue, though, is more complicated than just extrapolating past trends and then rationalizing away the concerns. At the 1980 SAE Annual Congress, a researcher from the State of Michigan reported that subcompact cars now have a lower accident rate than larger size cars - 8 accidents per million miles versus 11 accidents per million miles for intermediate, and 9.1 for full size and luxury cars.13/ Also, the National Highway Traffic Safety Administration recently released track test data from a variety of vehicles. Of the thirty three vehicles tested over the full spectrum of vehicle sizes, eight passed the test (an occupant protection 35 MPH barrier impact test). The vehicles which passed were spread fairly evenly over the range of cars tested, with no correlation to vehicle weight or size.

The concern about safety implications of the small-to-large vehicle crash may be valid, and could represent a substantial public barrier to the widespread acceptance of small cars. In fact, the number one concern expressed by the public regarding a transition to smaller, more fuel-efficient cars is safety.14/15/ Therefore, such concerns, whether valid or not, must be effectively dealt with to assure successful implementation of this initiative.

Safety concerns regarding small car-large vehicle crashes, the public resistance in general of switching to a small urban car, and the impact on the steel industry due to light weight efficient cars can to a large degree be resolved through the construction of a separate urban road structure for the new light-weight urban cars. The new separate roadway system would prohibit all trucks and non-urban cars by way of size and weight limitations. The new urban road system could be a second-level roadway above existing urban freeways and major arteries. Such new second-level roadways would use extensive amounts of steel, but because of the limitation of vehicle weight, the roadways could be of relatively low cost construction. The prohibition of heavy vehicle use would also reduce road service maintenance cost and allow for a more energy efficient and smoother-ride road surface (rough roads consume considerably more energy than smooth roads). The road system could also, in some cases, be expanded horizontally with urban car barrier protected lanes. In any case, since the number of vehicles and vehicle-miles-traveled will be increasing in urban areas anyway, which will necessitate new roads, so they might as well be urban-car-only roads. Since 1975 the Department of Transportation has been working to implement a concept known as Transportation System Management (TSM). The goal of TSM is to more fully utilize existing road systems. To the extent that TSM is successful, the building of additional urban roads can be delayed - an excellent opportunity to eventually phase-in an urban car road system as a means of expanding system capacity. Special privileged/priority parking for these urban vehicles would also accelerate their use.

In general, implementation of this initiative would not be expected to impose increased environmental impacts. The one exception is, however, the concern regarding the diesel engine's potential cancer health impact. However, with the PROCO engine and perhaps other engines as well, offering similar fuel efficiencies as the diesel, this initiative need not be rejected because of this concern. The cancer health implications of the Diesel engine should be resolved as expeditiously as practicable so that alternative fuel efficient engines or special diesel engine emission control technology can be developed, if the cancer health concerns so dictate. In the interim, encouragement should be given to the development of alternative engine technologies such as the PROCO and the development of control technology which is effective in reducing the biologically active emissions from the diesel engine.

On the bright side, however, is the likelihood that implementing this initiative will result in a technically superior "world car", with the domestic automobile industry generally being ahead of the U.S. market which would further encourage vehicle exportation (See Attachment 3 for further discussion.). The results of the U.S. having the technological lead on a "world car" are the likelihood of a positive balance of trade and increased employment of U.S. auto workers.

Implementation Options

Since the successful implementation of this initiative requires the stimulation of significant product and consumer preference changes, an information program alone is not expected to be effective.

A very large motor vehicle fuel tax would likely result in a vehicle fleet and energy conservation somewhat similar to that described here. The primary difference would be that such a large fuel tax would probably eliminate the large car from any usage by most people, whereas implementation of the initiative developed herein would continue to allow the use of the larger vehicle for trips for which it is most suited. If we let our energy consuming greed drive gasoline prices up to force us to cut back on consumption (independent of whether the prices are driven by market forces or by taxes), then we will still experience the same lifestyle vehicle-mix technology changes to get to the same place from a conservation standpoint, but we will do it by having to pay a very high price for the fuel we consume as well, and thus resulting in much larger life style impacts. If our message to the automotive industry is that we want fuel efficiency in the manner described herein, then we can obtain it without the loss of the family car or other special utility vehicles and without the need to pay excessive prices for the fuel we use. As is discussed elsewhere in this document, a modest economic stimulus would be of assistance in obtaining the objectives of this initiative. (For further discussion see the initiative, Economic Disencentives - A Tax on Imported Petroleum.)

Another stimulus would be to produce a new road network especially for the urban vehicle. This new network would only be necessary within the major urban centers and would likely provide a major stimulus to the introduction of this initiative. Additional discussion of this concept can be found in the Impacts section.

Regulations are definitely a mechanism whereby this initiative can be achieved. Regulations will also provide a clear and necessary message to the automotive industry regarding the products it will have to produce in the future. This is an important message in that a given company would not likely gamble and make the massive vehicle changes necessary without assurances that his competitors would likewise be making similar massive changes. Regulations provide a framework wherein orderly capital commitments and changes can be made without the risk and fear of bad competitive investments being made.

Maybe the time has come, however, for the merging of direct economic stimulus within a regulatory structure. The option is to establish a National Target mpg - a CAFE Target, with economic motivation. The current civil penalty associated with non-compliance with the CAFE standards (even with carry forward or carry back) has a bad connotation within the industry. This structure is characterized by the industry most frequently in such terms as: "we won't break the law; we have no choice but to sell the cars that will allow us to meet the standards, whether the public wants them or not." Much of the controversy associated with the current standards stems from this reaction, not issues of technical feasibility or even arguments over appropriate national objectives. (The automobile industry would certainly agree that energy conservation is in the national interest.) The challenge is then to clearly establish a national objective (or mpg target) driven by economic motivation. Specifically, the CAFE standard with civil penalties would be replaced with a CAFE target with the economic motivation of a fuel inefficiency tax or fee.

Consider the following possibilities, an 80 mpg CAFE target and a fuel inefficiency tax per mpg* per vehicle of: (1) $50 (the current civil penalty level), (2) $100, and (3) $200 (all 1980 dollars). For a manufacturer who sold only two car types, one which gets 80 mpg and the other which gets 50 mpg, and if the full tax was passed through to the 50 mpg vehicles, the extra cost per vehicle is $1,500, $3,000, and $6,000 for cases one, two, and three, respectively. The fuel consumed by the 50 mpg vehicle is 2,000 gallons. The vehicle tax for this vehicle is "equivalent" to a fuel tax (1980 dollars) of $0.81 per gallon, $1.63 per gallon, and $3.25 per gallon for cases one, two, and three, respectively (assuming 10,000 miles per year for 10 years useful life, an inflation rate of 8 percent, and a discount rate of 10 percent). However, a significant increase in the vehicle cost is likely to have a larger influence than an "equivalent" fuel tax spread out over the life of the vehicle. Manufacturers have historically minimized initial vehicle cost even though operating costs were substantially increased (e.g., the pre-1975 approaches to emission control). Another characteristic of the fuel tax is that the 80 mpg vehicle would also be required to pay the same fuel tax for the 1,250 gallons it consumes which is "equivalent" to a per vehicle tax of $934, $1,879, and $3,746 (1980 dollars) for cases one, two, and three respectively. If one considers the above vehicle tax possibilities from the perspective of how much it cost the 50 mpg vehicle purchaser per gallon of "extra" fuel consumed (using the same assumptions), the result is $2.17 per gallon, $4.34 per gallon, and $8.68 per gallon for cases one, two, and three respectively.

A manufacturer of course will likely have a large number of different vehicle models, each with a different fuel economy. The manufacturer is then free to develop his own stimuli to encourage people to buy the more fuel-efficient vehicles; he can set-up his own tax/rebate system if necessary to assure that he sells the "right" mix of vehicles to meet the CAFE target. The motivation for meeting the CAFE target is simply that a manufacturer could be at an economically competitive disadvantage relative to other manufacturers if he had to pay (and pass through to the consumer) fuel inefficiency taxes. Of course, it still might be possible that the paying of the tax might be the more profitable position. That is, the purchaser desires so much the fuel consuming vehicle that he is willing to pay the pass-through tax and a greater manufacturer profit. But perhaps that's the way it should be. It can be argued that it is "better" to apply the tax on the vehicle (the fuel consumption decision/commitment) rather than on the fuel, in that the purchaser retains more of a choice (with a fuel tax the consumer is locked into paying more for fuel without much of a choice, since he had previously made the fuel consumption commitment in the original purchase of the car - no matter how much he regrets it at the time he is buying his fuel). This is a concept that is rather well accepted.* Perhaps people should be allowed to retain the real choice between a space- and fuel-efficient, relatively inexpensive car and a large, heavy, gasoline-guzzling, expensive car - if they are willing to pay the price. But that price should have the built-in "cost" of the fuel consumption commitment associated with the purchase of the vehicle. As long as individuals are allowed to retain the choice to purchase fuel inefficient private airplanes, yachts, etc., so should individuals continue to be able to purchase the car they want, if they feel the price is worth the possession.

---

* A fuel inefficiency tax per mpg is non-linear. As a manufacturer's CAFE approached the target, the cost per gallon of fuel saved increases. This has the effect of pressuring the manufacturers harder to meet or exceed the CAFE target as compared to a fuel consumption based tax which would be linear.

But how is all this different from the current CAFE standards? In substance, it's not. In principle, it may be the difference between strong automobile industry opposition and reluctant supporters - if the "worth" of petroleum conservation can be agreed on.

Another implementation option would be the establishment of standards that are a function of vehicle utility (passenger carrying capacity) rather that computed on the basis of a corporate average. Such an approach would eliminate any arguments against the model mix changes that would be stimulated by an aggressive CAFE standard or target. If a fuel price increase stimulus is used, the marketplace may result in the fleet mix needed to achieve the CAFE levels desired by this initiative. If the model mix does not change significantly, then these utility based standards (requiring 70-80 mpg from 4-passenger cars, for example) would still achieve the bulk of the potential savings. However, with such an approach, the primary focus of argumentation would be on the appropriateness of dictating the design of the vehicle class - the removal of the flexibility for a manufacturer to comply with his own choice of technology and vehicle mix shifting.

The public acceptance of this initiative could be improved by paid advertising to encourage the public to buy more fuel efficient cars. Promotional advertising in the past has encouraged the use of energy consuming goods, such as the large automobile and its energy consuming accessories. Ideas like "Big is Beautiful," "Luxury means a big car," and "Your power is measured by the size of your car's engine" were very effective in selling Americans on the idea of buying big cars - but gasoline was inexpensive compared to other costs associated with owning a car. The times have changed. A good promotional campaign now to stress the positive aspect of smaller, more fuel efficient cars could be effective - ideas like high mpg cars are more personal, high mpg cars can give you intimate luxury, high mpg cars are more responsive on the road, high mpg cars are easier to maneuver and park, and of course, such cars can save a lot in terms of reduced fuel cost.

---

* For example, the public consistently expresses strong preference for a sales tax versus an income tax, since the sales tax doesn't apply unless you decide to buy a good.15/

An initiative that would cause a change of technology as great as the one described herein always has the potential suggestion of increased Federal R&D spending. However, this initiative is not based upon the need for dramatically new technologies or for research and development that could be best performed by the Federal government. Therefore, Federally conducted R&D does not appear appropriate, but as was discussed previously, there may need to be some form of Federal financial assistance provided to the automotive industry to allow them to do the job that has to be done.

As it is possible to compare the industry and lifestyle impacts of this initiative to passenger transportation mode-shifting, an energy efficiency comparison of these two basic options appears useful. Using as the primary reference the Urban Transportation and Energy: The Potential Savings of Different Modes prepared by the Congressional Budget Office in December 1977, the most significant conclusion of this study and other similar studies is that, of the conventional urban public transportation modes, buses appear to offer the greatest fuel savings. Therefore, the energy efficiency result of this initiative will be compared to the greater use of buses as the major urban transportation mode. Urban buses have an average energy intensity of about 2,600 Btu's per passenger mile, while the urban cars that would result from this initiative have an energy intensity of about 1140 Btu's per passenger mile (with a single occupant). The implementation of this initiative could then result in an energy efficiency of more than two times that of urban bus usage based on current bus load factors and fuel economy.

Recommendations

It is recommended that Corporate Average Fuel Economy Targets which apply to all passenger cars and light-duty trucks be set at 50 mpg in 1990 and 80 mpg in 1995. The targets should be supported with the economic motivation of a fuel inefficiency tax of $100 (1980 dollars) per vehicle produced by a manufacturer who is under the target CAFE, per mpg that the manufacturer is under the target CAFE. (With a target CAFE of 80 mpg, a manufacturer who had a CAFE of 70 mpg would pay a fuel inefficiency tax of $1,000 for each vehicle produced.) It is further recommended that the U.S. government set up a guaranteed loan trust fund for the domestic automobile industry during this period of major change. It is also recommended that the Federal government consider the construction of special roadways for the exclusive use of urban cars, whenever new urban road construction is warranted. All the recommendations of this initiative will require additional Congressional authority.

An alternative method of deriving a CAFE target would be to set a level representative of the best that can be expected from appropriately weighted urban and intercity mass transit systems. For example, with high load factors and efficient urban buses and intercity trains, a value of 800 Btu per passenger-mile seems reasonable. Using 125,000 Btu per gallon of gasoline and an assumed average of 2.2 passengers per vehicle mile, an equivalent CAFE target of 71 mpg results. Such a level is clearly technologically feasible. In addition, it can be argued that passenger cars should not be pushed beyond the most energy efficient alternatives, unless those modes were being pushed as well. However, operating energy efficiencies alone do not provide for an accurate energy efficiency comparison. For example, the Congressional Budget Office estimates the indirect energy efficiency for an average automobile to be 2,300 Btu/passenger mile and for an average urban bus to be 460 Btu/passenger mile. If indirect energy is considered and the automobile's indirect energy consumption cannot be reduced significantly (more than 50 percent), then an average passenger car cannot be as energy efficient as bus transport. Clearly, better data are necessary to allow a final conclusion using this methodology. In any case, a CAFE target significantly in excess of 71 mpg is likely.

Attachment 1

Table 3--Distribution of automobile trips by number of occupants for each purpose of travel - Residents of Standard Metropolitan Statistical Areas (SMSA'S)

Number of occupants	Major purpose of trip													
	Earning a living			Family business				Educational, civic, and religious	Social and recreational					All purposes
	To and from work	Related business	Total	Medical and dental	Shopping	Other	Total		Vacation	Visits to friends or relatives	Pleasure rides	Other	Total	
	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent*	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent
1	74.5	62.9	73.2	38.5	43.7	45.9	44.4	33.7	*	36.3	17.0	27.3	30.1	50.9
2	17.6	24.7	18.4	38.2	34.0	31.2	33.0	26.5	*	31.4	41.1	36.0	34.5	27.3
3	4.1	7.5	4.5	12.6	11.5	12.5	12.0	15.8	*	14.8	13.2	12.7	13.6	9.9
4	1.6	2.6	1.8	4.2	6.1	4.7	5.4	10.8	*	8.9	16.2	11.2	10.6	5.7
5	1.0	0.8	1.0	2.2	2.5	3.1	2.7	5.5	*	4.1	7.8	5.2	5.1	2.9
6	0.4	0.5	0.4	3.7	0.8	1.3	1.1	3.6	*	2.2	2.0	4.0	3.2	1.5
7	0.1	--	--	0.3	0.8	0.6	0.7	1.6	*	1.3	2.5	1.5	1.5	0.7
8	0.1	0.1	0.1	--	--	--	--	0.6	*	0.3	--	0.6	0.4	0.2
9 or more	--	0.3	--	--	0.3	0.1	0.2	0.5	*	0.3	--	1.0	0.5	0.3
N/A	0.6	0.6	0.6	0.3	0.3	0.6	0.5	1.4		0.4	0.2	0.5	0.5	0.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total number (000) of daily trips	53,033	6,716	59,749	2,755	25,937	21,407	50,099	14,844	244	14,068	2,036	20,088	36,435	163,964

* Available data not sufficient for analysis

SOURCE: Based upon unpublished table P-8 from the Nationwide Personal Transportation Survey conducted by the Bureau of the Census for Federal Highway Administration, 1969-1970.

Table 4.--Average occupancy in automobile trips classified by trip length and major purpose of travel

One-way trip length miles	Major purpose of trip										
	Earning a living		Family business			Educational, civic, and religious	Social and recreational				All Purposes
	To and from work	Related business	Medical and dental	Shopping	Other		Vacation	Visits to friends and relatives	Pleasure rides	Other	
Less than ½	1.3	1.4	2.0	1.7	1.8	2.4	*	1.9	1.6	2.5	1.8
1	1.4	1.5	1.8	1.8	1.8	2.6	*	2.2	2.8	2.2	1.9
2	1.4	1.6	1.9	1.9	1.9	2.6	*	2.0	2.4	2.5	2.0
3	1.3	1.5	2.0	2.0	1.9	2.6	*	2.2	2.3	2.6	1.9
4	1.3	1.7	1.6	2.0	1.9	2.5	*	2.0	2.3	2.5	1.9
5	1.4	1.7	2.2	2.1	2.1	2.4	*	2.3	2.5	2.7	2.0
6	1.4	1.4	1.9	2.1	2.0	2.1	*	2.1	2.8	2.7	1.9
7	1.4	1.8	2.1	2.2	1.9	2.5	*	2.5	2.6	2.6	2.0
8-10	1.4	1.6	2.2	2.2	2.1	2.6	*	2.1	2.9	2.6	1.9
11-15	1.4	1.8	2.7	2.5	2.1	2.4	*	2.2	3.1	2.6	1.9
16-20	1.5	1.9	2.6	2.3	2.1	2.0	*	2.6	2.8	2.6	1.9
21-30	1.7	1.6	2.3	2.6	2.1	2.3	*	2.7	2.6	2.9	2.1
31-40	1.5	1.6	-	2.1	2.8	2.9	*	2.2	2.1	3.0	2.3
41 and Over	1.6	1.6	3.3	2.5	2.8	2.9	*	2.7	3.2	3.4	2.6
Total all Lengths	1.4	1.6	2.1	2.0	1.9	2.5	3.4	2.3	2.7	2.6	1.9

* Available data not sufficient for analysis.

SOURCE: Based upon unpublished table T-5 from the Nationwide Personal Transportation Survey conducted by the Bureau of the Census for the Federal Highway Administration, 1969-1970.

Attachment 2

The EV Option

Electric Vehicle (EV) mpg ratings are of importance since an amendment to the Chrysler Corporation Loan Guarantee Act of 1979 allows the inclusion of EVs in a manufacturer's sales-weighted average fuel economy calculation. This gives the automobile industry another option which could raise fleet fuel economy values in the future.

The effect of an EV portion of the fleet depends on the base (non-EV) mpg, the percent EVs and the mpg assigned to EVs. DOE has not yet assigned the EV mpg values but it is known that they will probably range from 141 to 1000 mpg. We have highlighted two cases, 141 mpg and 500 mpg. The following table gives the percent EVs needed to get to a given fuel economy fleet average with the base fleet mpg being a parameter. Values of 27.5 mpg and 33 mpg were used for the base fleet. The table shows that the impact of the percent EVs is more important than the value of the EV mpg, for the EV mpg range considered.

Percent EVs in the Fleet Needed
to Obtain Various Fleet mpg Levels

	Base mpg 27.5		Base mpg 33	
Fleet mpg Level	EV mpg 141	EV mpg 500	EV mpg 141	EV mpg 500
40	38%	33%	22%	19%
50	57%	49%	44%	37%
60	69%	58%	60%	50%
70	76%	64%	70%	57%

What the table shows is that the assigned EV mpg value does not have a great impact until the percent EV gets above 20 percent or so. Also shown is that the base fleet (non-EV) mpg levels are also important. For example, if the base fleet level were 27.5 mpg, about 35 percent EVs would be required to get to a fleet mpg of 40 mpg, while a base fleet mpg level of 33 mpg would only require about 20 percent EVs to reach 40 mpg. If the time period to introduce these EVs into the fleet were about 10 years, for example from 1985 to 1995, this would imply 3.5 percent/year and 2 percent/year introduction rates respectively which means for a 10 million/year fleet the difference between 350,000 and 200,000 vehicles per year.

Relative Overall Efficiencies of Electric and Optimized Internal Combustion Vehicles

Much of the impetus for electric vehicles (EV's) has come from the realization that society must quickly provide an alternative form of personal transportation that does not rely on petroleum as its primary energy source, as do present-day internal combustion engines (ICE's). Though there are serious questions about the long-term survivability of any energy infrastructure that relies on nonrenewable energy sources, our most immediate concern in the transportation sector is to minimize the use of crude oil. EV's, by utilizing electricity from coal or other non-petroleum sources, have thus been touted as a promising method to reduce petroleum consumption.

It is now generally accepted, however, that liquid fuels for ICE's can also be produced from non-petroleum sources as well. While many authorities consider synthetic fuels from coal, shale, or tarsands to be preferable, we have concluded that a methanol-fueled fleet (with the methanol derived from coal or biomass sources) would be much more desirable from environmental and economic standpoints (see Section V). In any case, there is now a consensus within the automotive community that the ICE can be maintained for personal transportation (albeit likely a smaller, less powerful engine than Americans are used to) while at the same time reducing our reliance on crude oil, with its well known supply limitations and deleterious economic and environmental effects.

The logical question in this context is which type of vehicle is more energy efficient, the EV or the optimized ICE vehicle? A lively discussion of this question is now taking place within the automotive and energy fields, and no definitive answer is now available. Two recent Society of Automotive Engineers papers (800109, Efficiency of Coal Use, Electricity for EV's versus Synfuels for ICE's by H.G. Mueller and Victor Wouk and 800111, Impact of Electric Cars on National Energy Consumption by Paul D. Agarwal) have considered this issue, and have arrived at differing answers. Nevertheless, much of their various efficiency data agrees, and most of the data used below are taken from these two recent papers.

To facilitate the comparison, the efficiencies of both EV's and ICE vehicles will be estimated starting with an equivalent primary energy source--coal. One factor that will affect the efficiency comparison is vehicle weight. The Lawrence Livermore Laboratory has estimated that for an EV to have the same performance capability over 50 miles as a small, optimized two-passenger vehicle weighing 800 pounds, the EV would weigh 1000 pounds. Thus, the EV will be given a "weight factor" of 0.80 in the calculation below.

The various component efficiencies for EV and ICE vehicles are given below:

Electric Vehicles

Coal-Recovery and Transport	Electricity	Transmission
.98	.35	.91
Battery Losses	**Motor, Controls**	**Weight Factor**
.70	.75	.80

Overall EV Efficiency = 13%

ICE Vehicles (small diesels)

Coal-Recovery and Transport	Liquefaction	Transport
.98	.75	.99
Refining	**Distribution**	**Diesel Engine**
.90	.99	.30

Overall ICE Vehicle Efficiency = 19%

These calculations indicate that small, optimized diesels will be more efficient than EV's for 50-mile ranges. It must be noted that several of the component efficiencies above (notably the EV battery and motor and control losses and the ICE fuel liquefaction and engine efficiencies) are not well known at this time. And the EV efficiency calculation is very sensitive to the range required (and thus the weight of the batteries). For a 25-mile range the EV efficiency might well exceed the ICE efficiency, for a 100-mile range it would be much lower. Also, the efficiencies for EV's would be greater if the electricity used by them was generated at a power plant that utilized co-generation, i.e., if the "waste" heat was used to produce steam for space heating or industrial production. Once popular in this country, and still used extensively abroad, co-generation has not been used in this country for the last few decades.

The environmental implications of EV's and ICE vehicles are not clear. EV's have the advantages of the pollution being produced (and thus the possibility of being stringently controlled) at a few sources rather than at millions of sources. And the environmental problems of synthetic petroleum-like fuels from coal or shale are thought to be significant. But there is much evidence that the environmental problems of ICE vehicles can be minimized with the use of methanol fuel and with appropriate emission control technology.

Finally, there is the question of economics. There is considerable room for disagreement on this issue. The cost of large-scale liquefaction plants will doubtlessly be high, but the extra electrical generating capacity will be expensive as well. Though the economics of EV's versus ICE vehicles will likely be the deciding factor for the automotive industry in choosing which path to take, there is absolutely no consensus on this issue at this time.

Attachment 3

Being Ahead of, or Being Behind the Market

The following discussion is based on two assumptions: (1) that there will be fuel economy requirements in the future and (2) that the mpg requirements will not exactly match "what the market wants," and therefore, the standards will either be ahead (greater than) of or behind (less than) the market.

With respect to assumption (1), there appears to be no question that this will be the case for the future. With respect to assumption (2) one is faced with the question of predicting what the market wants; to see if the standards are ahead of or behind the market and also estimating what the market is likely to want in the future.

Figure A-1 shows a graphical indication of the market demanded mpg and dashed lines representing fuel economy standards that are either ahead of or behind the market.

Since the discussion is focused toward the future, it should be emphasized that nobody knows exactly what the market will want. However, it is likely that the market will experience major swings as events alter fuel price and availability. This means that the market is expected to be volatile and unpredictable. Consider the past. If these estimates were being made ten years ago in 1970 would we have predicted a) the Arab Oil Embargo?, (b) the Iranian Situation? (c) the doubling (in real dollars) of gasoline prices in about one year? Probably not, but the lesson to be learned from the past ten years is that the market will be volatile and unpredictable in the future.

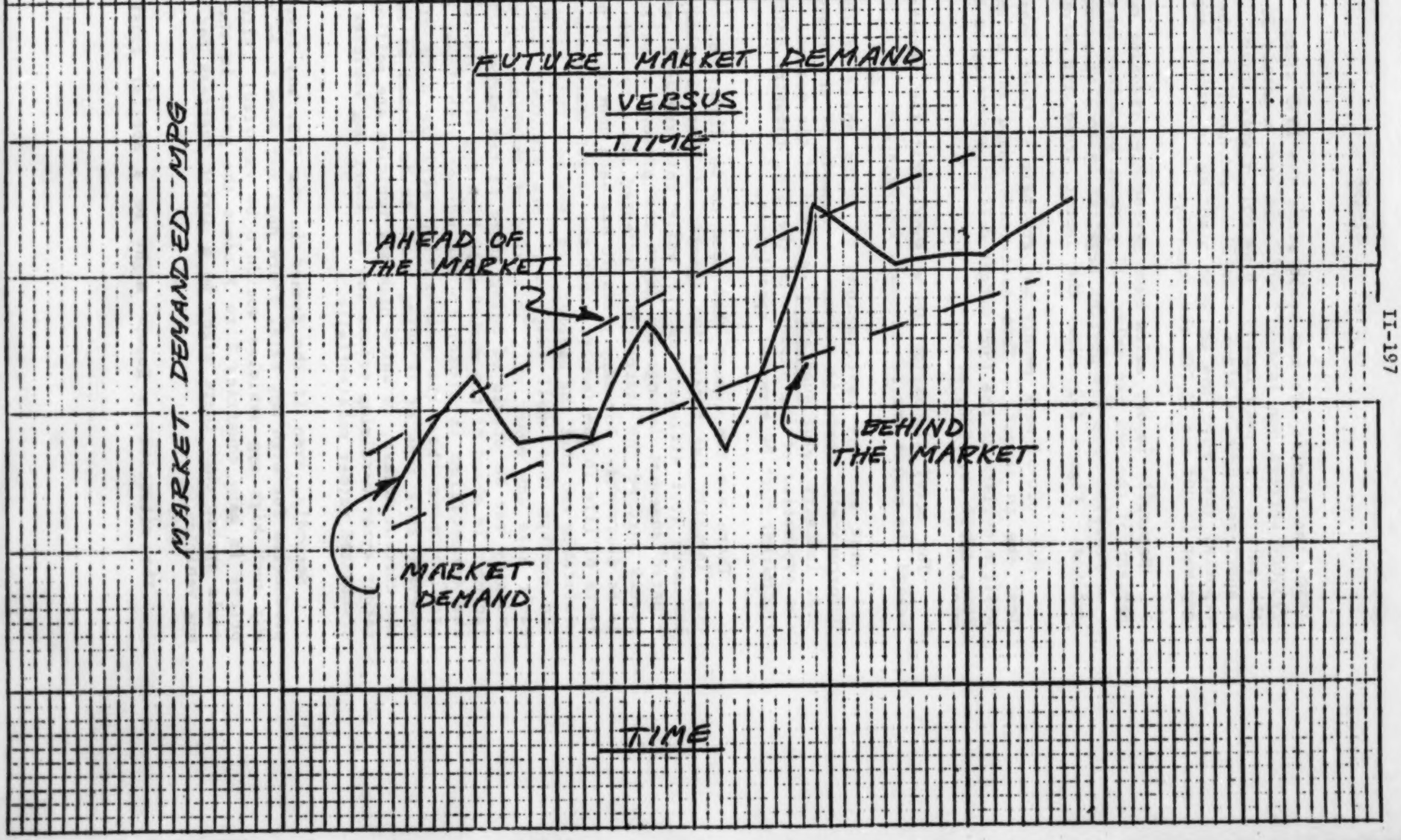
The difference between what the market wants now and the current fuel economy standards is a subject over which there is little disagreement as to the value of what the market wants.

An analysis based on the new car days-supply figures for vehicles of different mpg values yielded an estimate of market demand that ranged from 24 to 37 mpg. Our best estimate is that the market was demanding something a little in excess of 30 mpg about halfway through the 1980 model year. This is substantially in excess of the current mpg standards. Therefore it can be said that the current mpg standards are behind the market.

There are many impacts associated with being behind the market, and nearly all of them are negative.

First, since domestic car makers were planning to sell cars of lower mpg than their foreign competitors (about 22 mpg vs. 28 mpg), sales of U.S. cars have fallen. This is bad for the U.S. automakers and is nearly a disaster for their workers, many of whom are laid off. According to the Detroit Free Press, Friday, April 4,

Figure A-1


FUTURE MARKET DEMAND
VERSUS
TIME
MARKET DEMANDED MPG
AHEAD OF THE MARKET
BEHIND THE MARKET
MARKET DEMAND
TIME

1980, the layoffs are the worst since the 1975 slump. A total of 223,000 workers are laid off which is approximately 29 percent of the entire U.S. auto industry blue collar work force. This is not a short-term problem since on April 16 and April 17, the Free Press reported that Ford and GM were planning to reduce employment by another 15,000 and 12,000 respectively.

Naturally import sales have skyrocketed reaching more than 25 percent of the new car sales (27 percent according to the April 4 Free Press). This has obvious negative balance of payments implications. Figure A-2 shows the import trend for several years.

Many out-of-work people may get help if their jobs have been lost due to imports. This assistance could add as much as 1.1 billion dollars to the 1980 budget deficit according to Automotive News, April 14, 1980, p. 60.

The brief discussion above shows that the impacts of being behind the market are substantial, and negative.

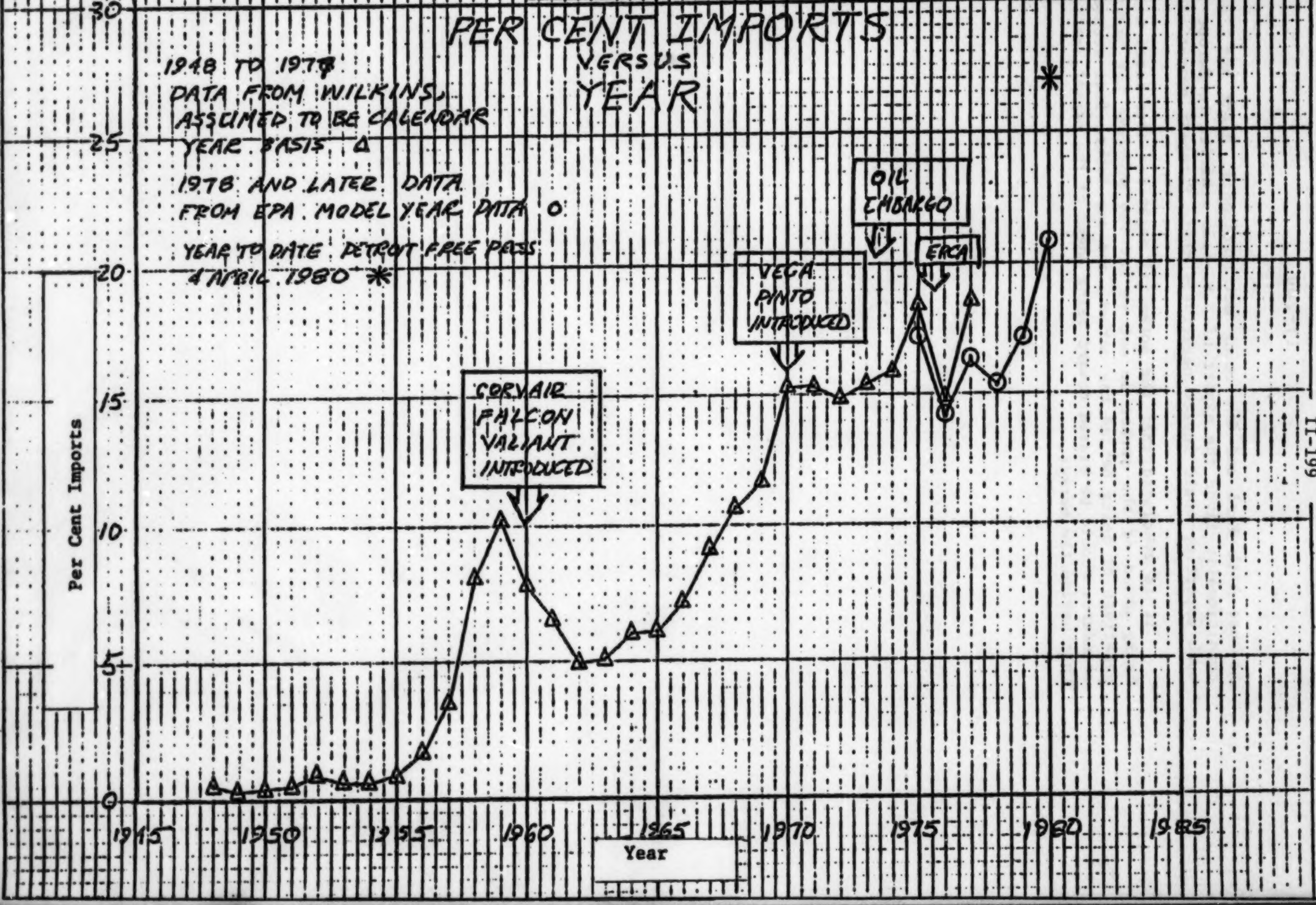
What are the implications of being ahead of the market? Unfortunately, there is no current example of the impacts of the U.S. industry being substantially ahead of the market. Therefore, the evaluation of the impacts of the U.S. industry being ahead of the market must be somewhat speculative.

There are two issues that need to be discussed. First, the U.S. industry has raised the specter of what if nobody will buy the more fuel efficient cars? While this statement may be considered somewhat incongruous given the present situation, it may reveal part of the historically accepted industry view that needs to be discussed. For many years it has been considered part of the facts of life in the industry that the larger vehicles are the most profitable and that the smaller ones less so. This has resulted in the concept that small (high mpg) cars are cheap cars that you can't make any money on. This kind of thinking may be why the industry may be afraid of being ahead of the market. If a manufacturer is ahead of the market with high mpg (low profit) cars and the competition is closer to the market with lower mpg (high profit) cars then the competition will be more profitable. However, this type of thinking needs to be looked at in light of the current market, in which high mpg vehicles are selling for some rather eyebrow-raising prices and the lower mpg vehicles are being discounted rather substantially.

Secondly, even if the demand in the U.S. was less than the production for high mpg cars, there does not seem to be any reason why such high mpg vehicles wouldn't be exported. With gasoline prices in many countries 2 to 3 times the price in the U.S., it would appear that there might be a market overseas for such high mpg vehicles.

The situation in Europe might be a special consideration,

Figure A-2



PER CENT IMPORTS VERSUS YEAR

1948 TO 1977
DATA FROM WILKINS,
ASSUMED TO BE CALENDAR
YEAR BASIS Δ

1978 AND LATER DATA
FROM EPA MODEL YEAR DATA O

YEAR TO DATE DETROIT FREE PRESS
4 APRIL 1980 *

because both Ford and GM, being multinationals, might not unconditionally favor the export of U.S.-made vehicles to Europe if such exporting would impact negatively their European operations.

It is concluded that the potential negatives associated with being ahead of the market do not in any way overcome the proven negatives of being behind the market, and any future fuel economy standards should be biased toward being ahead of the market, rather than behind the market.

References

1/ Running on Empty - The Future of the Automobile in an Oil-Short World, Brown, Lester R., Flavin, Christopher and Norman, Colin, W.W. Norton and Company, New York, 1979.

2/ U.S. Department of Transportation, "The Sensitivity of Projected Aggregate Fuel Consumption to the Conditions of Individual Fuel Economy Tests--Part A," May, 1974.

3/ "Technological Improvements to Automobile Fuel Consumption," A Report of the U.S. Department of Transportation and the Environmental Protection Agency (Report DOT-TSC-OST-74-39 IIA), December, 1974.

4/ "The Report by the Federal Task Force on Motor Vehicle Goals Beyond 1980," August 20, 1976.

5/ Nelson, Kenneth W., "Plastics in Vehicle Structures," An Article from Machine Design, February 7, 1980.

6/ "Ideal Aerodynamic Shape Now Ready for Real World," An Article by Jan P. Norbye, Automotive World News, March 26, 1979.

7/ Scott, David, "Belt-drive CVT for '82 Model Year," An Article in Automotive Engineering, February, 1980.

8/ John, Richard R. (DOT), Transition to the Post-1985 Motor Vehicle," Paper Presented at the First International Automotive Fuel Economy Research Conference, Washington, D.C., October 31-November 1, 1979.

9/ von Hippel, Frank, "Forty Miles a Gallon by 1995 at the Very Least," A Draft Report of the Center for Energy and Environmental Studies, Princeton University, Report Number 104, May 12, 1980.

10/ "U.S. Autos Losing a Big Segment of the Market - Forever?," An Article in Business Week, March 24, 1980.

11/ "The Highway Loss Reduction Status Report," A Publication of the Insurance Institute for Highway Safety, Volume 12, Number 7, May 9, 1977.

12/ Bunch, Howard M., "The Small Car May be Dangerous to Your Health! - The Consequences of Downsizing," A Paper Presented for the Symposium on Technology, Government and the Future of the Automobile Industry at the Harvard Business School, October 19-20, 1978.

13/ Lee, Martin E.H., Glover, Matthew F. and Eavy, Paul W., "Differences in the Trip Attributes of Drivers with High and Low Accident Rates," Society of Automotive Engineers Paper 800384 (SP-461), February 25-29, 1980.

14/ "A Study of Consumer Behavior Towards Fuel Efficient Vehicles, Task D: Focus Group Analysis," A Report of Market Facts - Washington, Submitted to the U.S. Department of Transportation (DOT-ITS-7-01781), May 1978.

15/ Schneider, William, "Public Opinion and the Energy Crisis," A Presentation for "The Dependency Dilemma: U.S. Gasoline Consumption and America's Security," Harvard University, March 22, 1980.

16/ Seiffert, Ullrich, Walger, Peter and Oetting, Herman, "Improvements in Automotive Fuel Economy," A Volkswagenwerk AG Paper presented at the First International Automotive Fuel Economy Conference in Washington, D.C., October 30 through November 2, 1979.

III. TRANSPORTATION MODE SHIFTING

The shifting of usage patterns among the modes of transportation to achieve an optimum fuel utilization efficiency offers substantial conservation potential. For intercity transportation, the shifting of passengers from automobiles and airplanes to buses and trains, and the shifting of freight transport from aircraft and trucks to trains (and where practical marine and pipeline modes) will provide the largest energy savings. For urban passenger transport, the shifting of people from automobiles to multiple occupancy commute vehicles and to the mass transit systems (buses and trains) will provide the largest energy savings. In addition, the reduction in the need for travel through such techniques as video phones also have a large potential for significant energy savings. The difficult problem with mode shifting is the reluctance of many people to make such changes. Another significant problem is how to accomplish such changes without serious and significant economic impacts on important components of U.S. industry and without major sacrifices being called for on the part of individuals.

Looking closer at the various urban passenger transportation modes, Table 1 presents the Btu's per passenger-mile ratings, which includes energy for propulsion, vehicle and guideway construction, and round-about journeys.1/

Table 1

Btu's per Passenger-Mile for Various Urban Transportation Modes

Mode	Btu per Passenger-Mile
Dial-a-ride	17,230
Single-occupant auto	14,220
Average auto	10,160
Heavy rail transit (new)	6,580
Carpool	5,450
Light rail transit	5,060
Commuter rail	5,020
Heavy rail transit (old)	3,990
Bus	3,070
Vanpool	2,420

This table clearly indicates that van pools and buses are the most energy efficient modes of urban passenger transportation. While heavy rail transit (old) has a very acceptable energy efficiency, other rail systems and especially new heavy rail transit systems are more fuel inefficient. The other key factor to consider, in addition to energy efficiency, is the cost of the transportation. Mass transit systems generally have the potential of being cost competitive with single occupancy automobile use, with the one possible exception of new heavy rail transit systems. The Congressional Budget Office concluded, for new heavy rail transit systems, "Even under wildly optimistic assumptions, . . . savings are equivalent to a price of about $50/bbl of oil" (1977 prices). There are good reasons for rail transit systems, and increased use of existing systems should surely be a part of any good energy conservation strategy; but new heavy rail systems should be questioned when considering cost and energy conservation potential. The costly and capital-intensive nature of new heavy rail systems is not shared by the bus or vanpool modes. These modes also share the advantages of not being tied to fixed guideways and of being able to expand or contract to meet new demands fairly easily. The major disadvantage of today's bus systems is the increased time spent in transportation. This is, of course, a result of the dispersed, low density residential patterns that have evolved in America's cities, and the need to pick up and discharge riders en route. In addition, the bus mode has additional disadvantages as compared to vanpooling , for example; drivers must be paid, and service must be maintained during non-rush periods. It is probably primarily the result of the perceived inconvenience of taking the bus that has resulted in the widespread need to subsidize transit lines.

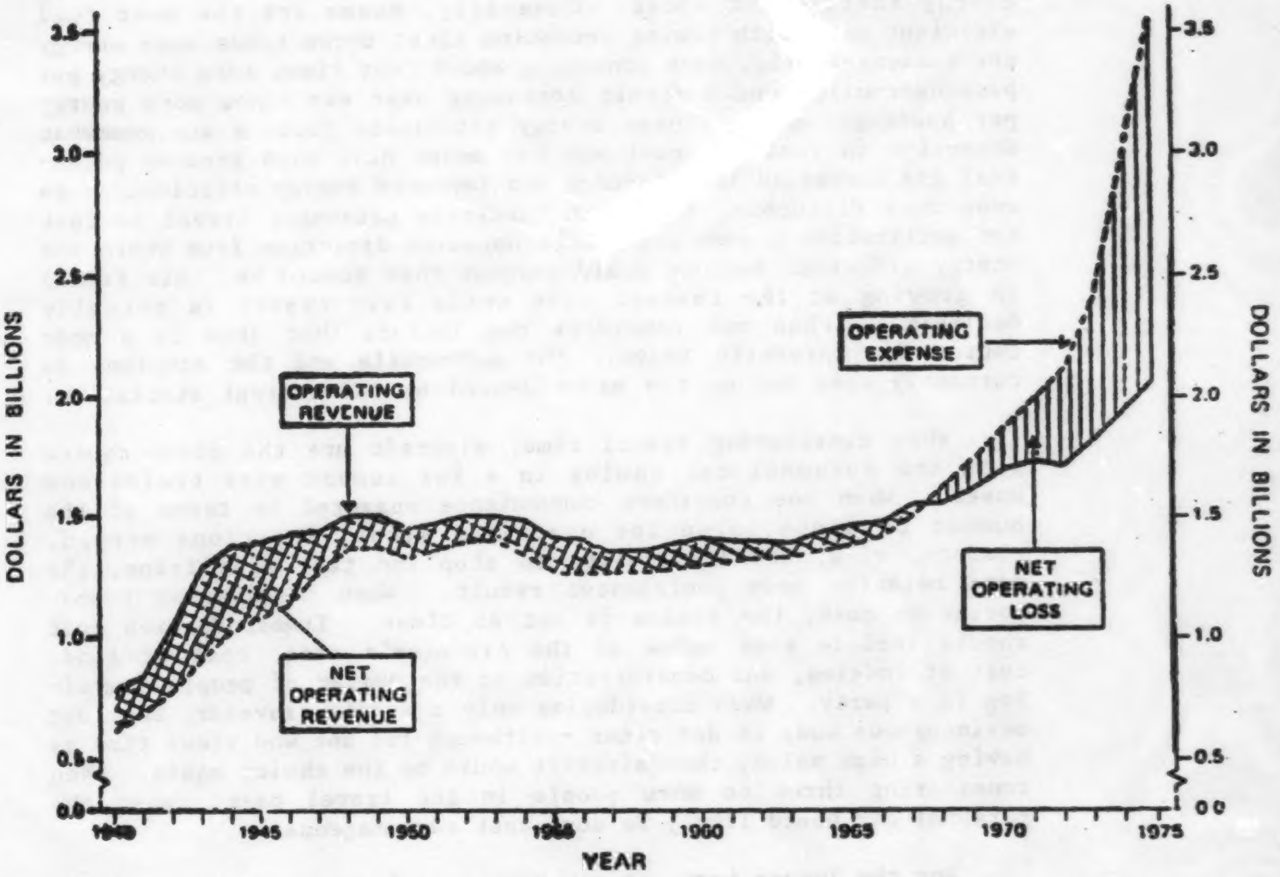
Figure 1 graphically illustrates this point with operating expenses almost doubling operating revenue.

It is clear that urban travelers have preferred the automobile mode, since only one passenger-mile in twenty-three utilizes public transportation. An elaborate transit system saves no energy at all without riders. The problem is one then of attracting the right people (especially single occupancy auto commuters) to ride the bus. The difficulty of attracting riders to the bus systems is that the automobile offers such an appealing alternative, measured in terms of convenience, low travel times, privacy, perceived cost (out of pocket expenses that are often comparable to transit), entertainment (via the car radio), and the personal control one can exercise in an automobile. The available data indicate that travel time is a far more important consideration than travel cost in making mode choices - a conclusion very consistent with the current choice of the automobile in preference to mass transit. Another consideration is that the work trip is likely to be more responsive to transit diversion than trips for any other purpose. Since work travel occurs during peak periods, it is more costly for transit to serve incremental work trips than other trip purposes. In addition, the work trip is of course the target of van pooling initiatives. Therefore, it seems most logical that transit fare reductions to stimulate ridership should primarily be used during non-commute periods to stimulate the overall growth in the use of the transit systems so as not to detract from van pooling or to build up a peak capacity that cannot be efficiently utilized during other periods.

Another general concern is that quick, efficient, attractive

FIGURE 1

NET OPERATING INCOME OR LOSS OF TRANSIT OPERATIONS 1940-1975



Note: This figure does not include taxes in the calculation of operating expenses

Source: American Public Transit Association, Transit Fact Book, '75-'76 Edition.

rapid rail systems may contribute to further dispersed living patterns rather than to more concentrated, and thus generally more energy efficient, urban areas. If it is assumed that for the majority of commuters the most important commuting mode choice is time rather than money, a rapid rail station in the suburbs allows one to live many miles outside the city and commute daily in little more time than it would currently take in commuting from one place within the city to another.

When considering the intercity passenger travel situation, the energy efficiency picture is again dismal. Here, the aircraft and the private car are the major transportation modes. But like the urban situation, intercity passengers have picked the most energy inefficient modes. Generally, buses are the most fuel efficient mode with trains consuming about three times more energy per passenger-mile, cars consuming about four times more energy per passenger-mile, and aircraft consuming over six times more energy per passenger-mile. These energy efficiency factors are somewhat deceptive in that the rail and bus modes have much greater potential for increased load factors and improved energy efficiency. An even more disturbing factor in intercity passenger travel is that the utilization trends are in the opposite direction from where the energy efficient factors would suggest they should be. Air travel is growing at the fastest rate while rail travel is actually declining. When one considers the factors that lead to a mode choice for intercity travel, the automobile and the airplane do currently come out on top as evidenced by the current statistics.

When considering travel time, aircraft are the clear choice with the personal car coming in a far second over trains and buses. When one considers convenience measured in terms of the number of stops, need for overnight stops, locations served, comfort, view, and flexibility to stop and take side trips, the same relative mode preferences result. When considering transportation cost, the choice is not so clear. Transportation cost should include some value of the traveler's time, cost of food, cost of lodging, and consideration of the number of people traveling in a party. When considering only a single traveler, the cost advantageous mode is not clear - although for one who views time as having a high value, then aircraft would be the choice again. When considering three or more people in the travel party, then the personal car would likely be more cost advantageous.

For the longer term, it may be appropriate to place a national priority on development of a system of fast trains to make this mode of transportation more attractive. In the near term, it would be difficult indeed to encourage Americans to shift to alternative forms of intercity transportation. In view of the rapid growth in the aircraft transportation mode, however, consideration should at least be given to reducing the current public subsidy to aircraft (estimated to be about 32 billion dollars from World War II to 1978).2/ Aircraft, for example, pay no tax on the fuel they consume.

In the previous set of initiatives, it was often likely that the dollar savings associated with the initiative were such that information programs or regulations on new products had a high likelihood of success. For mode shifting, however, a financial savings due to a shift may not be as readily apparent to the user. Information programs can certainly help. However, regulations and economic disincentives are strongly resisted. Therefore, economic incentives (or subsidies) have developed as a basic approach now being followed in an attempt to encourage mode shifting to the more efficient transportation modes. The basic question to be asked is though, why aren't these programs producing results? The passenger transportation mode shifting initiatives presented in this section are based upon the economic incentive for performance (measured in terms of increased ridership in the more fuel efficient transportation modes). The concept is: reward performance.

References

1/ "Urban Transportation and Energy: The Potential Savings of Different Modes," A Report of the Congressional Budget Office to the Congress of the United States, December, 1977.

2/ United States Conference of Mayors, "Federal Aid to Transportation", May, 1979.

Shift of Freight Transport From Truck to Rail Through The Elimination of the Government Subsidy Differential

Summary

Railroads currently move only 36 percent of total freight, down from 56 percent in 1950. The trucking industry's share has increased from 16 percent to 24 percent in the same period. The primary reason for this shift is the faster and more flexible service trucks offer. However, trucks would not have been able to compete as well in terms of price if they had not been subsidized heavily by the government through highway construction and maintenance. Railroads must construct, maintain, and pay taxes on their tracks and road beds, giving them a large overhead of fixed costs. In comparison, trucking is essentially a variable cost business, during slow periods trucks do not pay as much in user taxes, and have no rights-of-way to maintain.

In order to encourage the movement of freight from truck to rail several options are available to the government:

1. Direct subsidy of railroad track and road bed investment and maintenance.

2. Federal loan guarantees for railroad track and road bed investment and maintenance.

3. Nationalization of railroad tracks and road beds with subsequent no-strings, no-cost, long-term leasing to railroads.

4. Nationalization of railroad tracks and road beds, with governmental responsibility for both construction and maintenance, as is now the case with highways. This option has been investigated by other parties and will continue to be a point of discussion in the future.1/ The complete analysis of the issues raised by nationalization with full governmental control (as opposed to the lease-back mechanism of the previous option) are beyond the scope of this initiative.

5. Energy tax credits for businesses which switch freight from truck to rail.

6. Truck user fees designed to assure that trucks pay their impact-based share of highway costs.

Each of these options has its advantages and disadvantages,

the success of any of them depends upon integration into a cogent program. The program that we recommend has three major components:

1. A five-year, $5 to $20 billion federal grant program to subsidize the railroad companies on a per-track-mile basis.

2. The enactment of a nationwide weight-mileage fee program for freight trucks based on gross vehicle weight, maximum axle loading, and mileage. It is estimated that this program would approximately double the $4 billion in user charges now paid by heavy trucks.

3. The offer, on a company by company basis, of the federal government to nationalize rail rights-of-way with no-cost, long-term leasing back to the railroad companies with no strings attached (a 0.451 billion dollars per year "cost" in terms of eliminated state and local property taxes).

The short-term federal grants would be an attempt to "rebuild" the rail tracks and road beds by providing funding for the necessary maintenance which has been deferred. These grants would be partial "compensation" for the public monies that have been used for highway construction and maintenance in the past, and would allow railroads to become much more competitive with trucking in the near term. Fair weight-mileage fees would allow railroads to compete with the trucking industry on a more equitable basis and would thus benefit rail's position in the long term. Optional (to the railroad companies) nationalization with long-term leasing back to the railroad companies would allow the companies relief from the state and local property tax burdens which they presently pay.

The most critical impact this initiative will have is an increase in the percentage of freight carried by the railroads, and a decrease in the trucking industry's percentage. However, because none of these options can be implemented immediately the effects are likely to be spread out over a number of years, so that there should be a slow growth in railroad freight and a slow decline in trucking. Clearly, not all freight could be shifted from truck to rail even in the most optimistic scenario, and the expected growth in total freight shipped will probably compensate for the decline in the percentage of freight moved by truck.

To estimate the fuel savings possible from this initiative, we have assumed that the amount of freight hauled by intercity trucks will remain at 1980 levels, and that the growth otherwise expected in the trucking industry will all be absorbed by the railroads. Utilizing the fact that rail uses only 27 percent of the fuel that trucks require for the same shipment, this initiative would save 306,000 barrels of fuel daily in 1990 and 534,000 barrels of fuel daily in 2000.

Another major impact of this initiative would be greatly improved highway safety. Fatalities in accidents involving heavy trucks numbered over 4,600 in 1978, and are increasing; trucks are, in many places, getting longer and heavier while passenger vehicles are becoming smaller and lighter; and passenger vehicle occupants are almost always killed in passenger vehicle/heavy truck accidents no matter who is at fault. It is estimated that between 3,000 and 5,000 lives would be saved annually by 2000 should this initiative be implemented.

This initiative involves a major economic impact on the federal government as it would have to budget between $5 and $20 billion for the grants to rebuild the rail tracks and road beds. Fortunately, these grants could be spread over a five-year period. Governmental expenses for the other programs would be relatively minor. The weight-mileage fee program will have a significant economic impact on truck owners, possibly doubling their present user charges. But highway programs must have additional revenues, and it is most equitable to require the trucking industry to increase its user charge share.

The initiatives recommended here will help eliminate the current discrimination against railroads, putting them in a position to compete fairly with the trucking industry, while helping achieve our energy goals. Clearly it is in the national interest to have a healthy network of fuel-efficient railroads.

Assuming that by 1990 the federal grant program would have cost $20 billion, that five years of the nation wide weight-mileage fee program produced $20 billion, and that five years of nationalized rail rights-of-way cost $2.25 billion in revenues; then the 18.4 billion gallons of fuel saved through 1990 would be at a "cost" of 12 cents/gallon. Of course, beyond 1990, the increased weight-mileage fee would become the source of significant additional government revenues while resulting in continuously growing fuel savings.

Background

A. Overview of the Freight Industry

Intercity freight transport is an indispensable part of the national economy. In 1978, approximately 2.3×10^{12} ton-miles of freight were transported by intercity shippers.2/ Of this total, 36 percent was shipped by rail, 24 percent by truck, 24 percent by pipeline, 16 percent by inland waterway, and only a fraction of one percent by air.3/ This initiative is concerned with two of the most important freight transport modes, rail and truck. The other two primary modes, pipeline and inland waterway, are very energy efficient, but both are limited in the amount of freight they can transport -- the former because of the relatively few products that can be shipped via pipeline, and the latter because of the limited routes available.

Rail and trucks often compete for the same types of freight. In fact, possibly as much as 70 percent of all rail freight revenue is from freight that is (or could be) also shipped by truck.4/ As will be shown below, freight transport by rail is more energy efficient than truck freight. Despite this, the percent of all intercity freight shipped by rail has decreased from 56 percent in 1950 to 36 percent in 1977. The gainers have been the energy-efficient pipelines (from 12 percent in 1950 to 24 percent in 1977) and the less-energy-efficient trucks (from 16 percent in 1950 to 24 percent in 1977).5/ While trucks transport less than one-quarter of all intercity freight, they use approximately half of all energy used for intercity freight shipment.6/

The underlying assumption of this initiative is that there is some (likely considerable) portion of intercity freight which could be shifted from truck to rail. This is not to say that the trucking industry is unnecessary or undesirable, in fact, the truck freight industry is essential to our economy. Many rural areas and small towns and cities have no alternatives to truck transport. The flexibility and timely nature of truck transport is essential to the shipment of time-sensitive goods, and goods with several unique destination points.

B. Expected Growth in Rail and Truck Freight Transport Barring Major Governmental Policy Initiatives

The primary effect of the trucking industry on the rail freight industry has been in terms of profitability, as trucks have taken over the shipment of many of the more valuable commodities leaving rail with heavy, bulky commodities like coal, grain, and steel. In 1955, one year before the beginning of the Interstate Highway Program, rail freight companies had profits of 1.8 mills per ton-mile. In 1978, profits were down to 0.5 mills per ton-mile.7/ Most predictions are that, barring major conservation initiatives, both the rail and truck freight industries will grow at approximately the same rate in the near future, with both modes doubling their total freight ton-miles by the year 2000.8/

C. Differential Impacts of Government Programs on Rail and Truck Freight Transports

There are two primary differences in the way in which government deals with the rail and truck freight industries. One, while rail beds and the land which they occupy are privately owned by railroad companies, and thus taxed by state and local governments, highways are public property and are not so taxed. Two, since highways are constructed and maintained with government money, trucks are required to pay user taxes which, in theory, are supposed to be fair payment for their use of the road system. These two areas will be examined further.

1. Property Taxes on Rail Property

There are two issues with respect to the equity of state and local property taxes on railroad property, which totalled $451 million in 1977.9/ One is whether or not the level of taxation of rail property is fair. Railroad property is often assessed at higher rates than other commercial and industrial property.10/ At one time, when rail freight had little competition and when profits were very high, such taxation was not considered unfair. At this time, however, such taxation policy must be considered discriminatory. The Railroad Revitalization and Regulatory Reform Act of 1976 (4R Act) prohibits such discriminatory taxation, but many states still practice such policy. It is estimated that discriminatory taxation costs the railroads as much as approximately $100 million annually.11/

The second, and more critical, issue is whether rail property should be taxed at all. Rail's primary competitor, the trucking industry, pays no property taxes on its rights-of-way since the highway system is owned by various levels of government. Various options should be considered that would equalize the rail/truck burden with respect to property taxes. As noted above, the revocation of state and local property taxes on railroads could save the railroads approximately $451 million annually.

2. Truck User Charges/Highway Construction and Maintenance

The primary impetus that government has provided to the truck freight industry has been the extensive highway network constructed during the last half-century, specifically the interstate highway system built in the last quarter-century. The capital expenditures required for the extensive highway network have consistently accounted for the largest share of government transportation costs. Highway construction and maintenance will continue to demand huge governmental investments. It has been estimated that $294 billion (1975 dollars) of capital will need to be provided by government between 1976 and 1985 for highway construction and maintenance.12/ Public funds finance the building, maintenance, operation, and administration of public roads; the level of government responsible and the method of generating revenue vary widely. Highway construction has traditionally required the greatest proportion of funding; the federal government provides 75 percent of the funding for most federal-aid highway projects and 90 percent of the funding for interstate highways, with state and local governments providing the rest. Highway maintenance is the responsibility of state government, though federal funds are obtainable through the highway trust fund for major improvements on federal-aid highways (resurfacing, restoration, and reconstruction).

The beneficial impact of the national highway system on the freight trucking industry has been considerable. There is now highway access to practically every settlement of a few hundred people or more in the country. The interstate highway system alone, superimposed on an already impressive highway network, reduced typical truck trip delivery times by approximately 20 percent.13/ There can be little question that the formidable highway construction program that has occurred over the last thirty years, and best typified by the interstate highway system, has contributed significantly to the ability of trucks to garner increasing shares of the intercity freight market.

While most American citizens have benefitted, in one way or another, from the construction and maintenance of the national highway system, not everyone has benefitted to the same degree. Thus, it would have been very unfair to simply use general tax revenues to completely finance the construction and maintenance of federal-aid highway projects.

Highway construction programs are a somewhat complex subject to attempt to analyze, due to the interaction of the federal, state, and local governments in many highway programs. Looking at government as a whole makes the problem considerably easier. In 1978, $31.8 billion was spent for highway construction, maintenance, operation, and administration. Of this $31.8 billion, 65 percent came from imposts on highway users, in the form of excise taxes (on fuel, new vehicles, truck parts, etc.), user taxes (for trucks), carrier fees (for trucks), registration fees, and driver's license fees. 23 percent came from general revenues and 12 percent came from investment income and borrowing.14/ While it is not possible to say that non-users do not benefit at all from the highway system, it certainly seems that they should not be responsible for 23 percent of the financial burden. As the highway budget becomes more and more dominated by maintenance expenses, the case for using general revenues becomes weaker and weaker; once the highways exist, it seems clear that the users which cause wear and damage should bear the replacement cost.

Also at issue is the 65 percent of the highway funding that is provided by user charges. Are these charges apportioned equitably among various users? To answer this complicated question it is necessary to examine the funding mechanisms for highway construction in the past.

Construction costs have typically been divided between "common" costs and "incremental" costs. Common costs are those costs which are necessary regardless of the type of user expected on the highway and include, for example, the cost of the pavement with a minimum width and a minimum thickness. Because common costs are independent of the types of users, the financial burden for common costs have been shared by all users, typically in the form of fuel taxes, which charge various users in the proportion with which they consume fuel. Any additional pavement strength, width, or thickness that is required by a highway to accommodate heavy freight trucks is then charged as an incremental cost, which is charged to heavy trucks in the degree in which heavy trucks necessitate the more costly designs. These incremental costs have typically been funded by the user tax assessed on heavy trucks.

In the past, approximately 70 percent of the total costs of the construction of a highway have been assessed as common costs, with just 30 percent of the entire costs assessed as incremental costs.15/ Thus over two-thirds of the costs of a highway construction project have been borne by all users, generally, as pointed out above, in terms of the fuel tax. Has this breakdown of common/incremental costs been fair? Let us quote one study on the subject:

> "When roads are built, the pavement is engineered to last 30 years with one resurfacing at 15 years. To determine how strongly a highway must be constructed to fulfill this goal, a traffic survey must be conducted and estimates projected as to the number of axles loaded at a particular load limit can be expected to travel on the roadway during the pavement's engineered life. This method takes into consideration stress due to the amount of truck traffic and the amount of stress delivered by the weight of each axle. The amount of car traffic can almost be disregarded on engineering factors for thickness of pavement because one 5-axle truck loaded at 18,000 pounds single axle limit causes as much wear to the roadway at 6,000 automobiles traveling over the same pavement."
>
> "As the number and/or the weight of the loaded axles crossing the pavement increases, the thickness of the pavement must increase to withstand the additional stress. As the thickness increases so must the cost of pavement. According to a study conducted by the Indiana State Highway Commission and the U.S. Department of Commerce, using as a standard a 20-foot-wide , one-mile-long slab of reinforced concrete pavement at 1977 bid price at a projected traffic volume of 100,000 axles, a pavement 3.8 inches is required at a cost of $56,000.00 per mile. Increase the projected volume to 10,000,000 axles and the pavement must be 8.4 inches thick at a cost of $145,000 per mile. Because of a 1977 traffic survey by Long Range Planning of the Highway Commission of Indiana roads, it has been projected that a 13-inch pavement will be required on any new interstate construction in this state at a cost of $211,200.00 per mile."16/

Thus, increasing pavement thickness from 3.8 inches to 8.4 inches increases pavement construction costs by almost three times. This need for greater pavement thickness is almost exclusively a function of the amount and weight of truck traffic expected on the highway. This type of evidence makes it clear that the 70/30 breakdown for construction costs is not equitable. A Bureau of Public Roads study in 1970 confirmed this conclusion. It found that combination freight trucks paid 23 percent less than their fair share of highway construction costs.17/

The situation is worse with respect to highway maintenance, which, because most major highway construction has already been completed, will assume a greater and greater proportion of our national highway budget. It is clear that truck/axle weights and truck/axle traffic are the primary parameters in pavement wear and pavement damage. It is generally accepted that one 80,000 pound truck causes the same amount of pavement damage per mile as 6,000 to 10,000 passenger vehicles (and cars are becoming lighter and lighter, causing even less damage).18/19/ In 1974 the Oregon Department of Transportation determined that heavy trucks would be responsible for 79 percent of surface maintenance (with 20 percent attributable to the weather and 1 percent to passenger vehicles) and 40 percent of total maintenance costs.20/ The situation has worsened in the last six years. Since 1974, most states have raised their maximum weight limits to 80,000 pounds. This increase will accelerate pavement deterioration by 25 to 40 percent according to the American Association of State Highway and Transportation Officials.21/ Inflation is also worsening the highway maintenance problem. Since 1975, highway maintenance costs have risen almost 50 percent.

But while it is clear that maintenance costs are becoming a greater and greater percentage of highway costs and that heavy trucks are responsible for a large percentage of highway maintenance costs, the federal and various state governments still rely on a taxing system that relies most heavily on the fuel tax, and as such, receives most of its funding from owners of cars and light trucks and not from owners of heavy trucks. The fuel tax provides 60 percent of all state user charges and 70 percent of all federal user charges.22/ Yet, since heavy trucks consume about 10 percent of all highway fuel, they contribute only about 10 percent of all fuel taxes. There are special state motor carrier taxes and federal excise taxes which apply exclusively to heavy trucks, but these revenues are a very small part of total user revenues. Overall, heavy trucks pay about one-sixth of all state user charges and about one-quarter of all federal user charges. In all, they pay approximately one-fifth of all federal and state user charges, or about $4 billion, while owners of automobiles and light trucks pay four-fifths of total highway user charges. Thus, while heavy trucks are clearly the primary cause of highway wear and damage, they pay only about $4 billion annually in user charges, which is only one-fifth of all user charges and one-seventh of total highway expenditures.

This analysis has attempted to break down the discussion into two parts -- the questions of highway construction and highway maintenance; while many studies have shown that heavy trucks have failed to pay their fair share of either set of costs, it seems clear that the situation is worsening as more and more of the highway budget is going for maintenance. Other studies have attempted to analyze the entire highway cost allocation question in general. An Urban Institute Study in 1977 found that as of 1975 heavy trucks were just making enough payments to offset direct use-related pavement deterioration costs -- they were making no contribution whatsoever to the common costs of highway construction.23/ Many states have also performed cost allocation studies showing that existing heavy truck user charges are too low. According to the Arkansas State Highway and Transportation Department, considering road damage on a proportional basis, cars pay 1160 times as much in taxes and fees as a 73,280 pound truck. According to a 1978 Georgia study, four-axle and five-axle trucks paid only 51 percent of their highway cost responsibility.24/ Oregon, California, and Florida have reached similar conclusions.25/

In conclusion, a few basic facts must be emphasized. 23 percent of all highway expenditures came from non-users in the form of general revenues, thus all taxpayers subsidize those users which use the highways the most and which damage and wear out the system. Of the payments that do result from user charges, only one-fifth of the funding is provided by heavy trucks, which cause a disproportionate amount of highway damage, while four-fifths is provided by owners of cars and light trucks. Thus, general taxpayers and owners of passenger vehicles are now subsidizing the heavy trucking industry. Unless changes are instituted soon, this subsidy is likely to increase as maintenance becomes a greater part of the total highway budget. To the extent that these subsidies enhance trucks' competitive position in comparison with other forms of freight transport, such public policy increases the inefficiency of the freight hauling system.

Fuel Conservation Potential

According to a recent DOE report, the average freight energy intensity of rail is approximately 676 Btu/route-ton-mile while the average freight energy intensity of trucks is approximately 2500 Btu/route-ton-mile.26/ Thus, rail uses only about 27 percent of the energy that trucks use to move the same mass of cargo the same distance.

It is very difficult to predict precisely the percentage of freight now shipped by truck that would be switched to rail freight by the implementation of the program recommended in this initiative. None of these programs could be implemented immediately, and shippers would need time to analyze the impacts of improved rail service and (likely) more expensive truck service. In any case, it is clear that there would be increased growth in the rail industry. As a first approximation, we will assume that the shift from truck to rail would approximate the expected growth in the intercity trucking industry over the next 20 years, i.e., the intercity trucking industry will continue to consume about the same amount of fuel in 1990 and 2000 as it did in 1980. Predictions have been made that, barring major policy shifts (such as the ones proposed here), intercity trucks would consume 1,181,000 barrels of fuel daily in 1980, 1,600,000 barrels of fuel daily in 1990, and 1,913,000 barrels of fuel daily in 2000.27/ Assuming that intercity trucking remains at its 1980 level, and that rail would use 27 percent of the fuel that trucks would require to move the same freight, this initiative would save 306,000 barrels of fuel daily in 1990 and 534,000 barrels of fuel daily in 2000.

Implementation Options

As has been discussed above, there has been a differential subsidy shift in favor of truck freight as opposed to rail freight. This subsidy differential has been manifested most directly in the inadequate proportion of highway user fees paid by heavy trucks, and by the property tax burdens which railroads must pay on their rights-of-way but which trucks do not. This suggests three ways in which the situation could be remedied: action to "compensate" the railroads for the past differential subsidies, action to assure that heavy truck users supply an equitable proportion of highway user fees, and action to relieve railroads of the state and local property tax burdens. These will now be discussed in greater detail.

A. "Compensation" for Past Differential Subsidies

There are a number of options available to the government in attempting to "compensate" for the historical subsidy differential in favor of truck freight, including direct federal grant subsidies, federal loan guarantees, and energy tax credits to businesses which switch their freight from truck to rail. The primary consequence of the past subsidy differential has been a depression of railroads' profitability. This, in turn, has led to an inability by the rail companies to maintain their tracks in good condition. Thus, we believe that direct federal grants are necessary to allow the railroads to immediately improve their tracks without going far into debt. Loans and energy tax credits simply do not allow this same short-term improvement in the railroad's service capabilities.

The amount and timing of these federal grants could be a source of further study. However, the total of all deferred maintenance and capital investments by the railroads has been estimated to be in the range of $5-20 billion.28/ In recognition of the annual highway budget of over $30 billion annually, it seems that grants of this order would be acceptable. The economic impact of the grants could be diluted by spacing them out over a period of approximately five years, which would make sense since most of the necessary capital improvements could not occur overnight. The grants could be made to the various railroads on a track-mile basis, and could be made contingent on the grounds that all the grant money be used for maintenance of tracks and bed "rebuilding" and that company short-term profitability not be significantly altered.

B. Ending Government Subsidy of the Trucking Industry

1. Background

As has already been discussed, trucks have long been subsidized by taxpayers through highway construction and maintenance. This subsidy is becoming larger as trucks become heavier (while cars become lighter) and more numerous, resulting in increased damage to our roads. Aside from the fact that railroads receive no such subsidy for track construction and maintenance, it is questionable whether government can afford to continue this subsidy. There is a growing crisis in highway finance that will make it imperative to extract higher user fees.

Highway maintenance costs have skyrocketed in the last few years and are continuing to do so. Many highways, especially those that were built early in the interstate program, are for the first time requiring major maintenance. Recent changes by many states increasing the maximum weight limits have increased the rate of pavement damage, as the stress and impact on pavement increases almost exponentially with weight per axle loading.29/ Finally, inflation means that almost twice as many dollars are needed today for a certain amount of maintenance than were needed eight years ago. Thus, in terms of revenues needed, dollars that are worth less and less are attempting to maintain a highway system which is rapidly deteriorating from age and heavier axle weights than it was designed for.

In terms of revenues available, the situation is also not good. The fuel tax continues to be the primary contributor to highway funding, but highway fuel consumption, due to occasional shortfalls, much higher prices, and more fuel efficient vehicles, has not been rising significantly. Thus, revenues from the fuel tax have risen only slightly. Truck user taxes, the other major component of total user charges, have also remained largly constant. Thus, incoming revenues have risen only slightly while maintenance dollar requirements have escalated greatly. Many states are finding themselves in severe highway financing difficulties and are unable to fulfill their maintenance requirements.

2. Options

In view of the increasingly severe highway financing problems discussed above, concrete action will have to be taken in the near future to increase the funding available to State agencies for highway maintenance. There are three general ways that such funding could be raised: 1) by using additional funds from general revenues, 2) by raising the fuel tax, and 3) by raising heavy truck user fees. All of these methods would be politically difficult to implement. But we believe that equity demands the third option to be chosen. Choosing either of the first two would exacerbate the situation whereby trucks already pay less than their fair share for highway construction and maintenance.

What is now necessary, and what has been lacking in our highway financing policies, is to begin allocating the cost responsibilities to users in proportion to the damage they cause. Heavy trucks especially cause more damage than they pay for. The three primary parameters in determing the damage inflicted by a heavy truck are gross vehicle weight, axle weight, and mileage. A user fee system which assessed charges on a total and axle weight-mileage basis would thus be the most appropriate mechanism available. Termed "third structure" taxes, weight-mileage user charges have in fact been instituted in several states, including Colorado, Oregon, New York, and Ohio.30/

States have designed two basic ways to administer weight-mileage fees. One method, presently utilized in Colorado, requires weighing each truck as it enters the State, and recording its movements through the State. The charges are then calculated on an actual ton-mile basis. This is a very accurate setup, but relatively expensive in terms of personnel, paperwork, etc. The second method, used in Oregon, uses the trucks' gross vehicle weight rating (and not its actual weight, i.e., it is taxed as if it were fully loaded even if it is not) and involves the auditing of trucking records to determine mileage. Thus, this design charges not actual ton-miles but the maximum ton-miles which could have been hauled. This method is much less accurate, but much cheaper to administer. The latter system generates one-quarter of Oregon's user charge payments, with only 2.5 to 3.0 percent of the revenues needed for administrative purposes.31/

Unfortunately, none of the state weight-mileage fees now in place consider axle weight, which is the single most important parameter in determining the effect of a heavy truck on pavement life and damage. To be most equitable, a weight-mileage tax should consider gross weight, axle loading, and mileage.

We recommend that weight-mileage fees based on total weight, axle loading, and total mileage be adopted on a nationwide basis. They are the most equitable means of raising funds for highway maintenance.

3. Implementation

Implementation of nationwide weight-mileage fees would not be easy because it would require positive action by the various state legislatures and transportation departments.

For an efficient and equitable weight-mileage fee system, we believe that federal coordination will be required. Every commercial freight truck engaged in interstate commerce would be required to obtain a federal registration and license. As part of this process, each truck's gross vehicle weight rating and maximum axle loading rating would be reported by the owner (in both cases, what the owner reported to be the maximum weight the truck would carry, not what the truck could carry), and each truck's odometer would be calibrated to a maximum diameter tire. At the end of each year, then, the odometer readings could be compared and the annual mileage computed. The annual mileage, the gross vehicle weight rating, and the maximum axle loading rating would then determine the weight-mileage fee, which would be paid to the federal government. Based on Department of Transportation truck vehicle-miles-traveled statistics for each state, these monies would be returned to the states for highway maintenance.

As described above, the weight-mileage fee should be dependent upon three parameters: annual mileage, gross vehicle weight rating, and maximum axle loading rating. One simple method would be to express the fee in mills (tenths of a cent) per ton-mile with different rates for different classes of maximum axle loadings. The sensitivity of pavement damage and highway life to axle loading is demonstrated in Table 1.

Thus, for example, a 12,000 pound axle loading does twice as much road damage as a 10,000 pound axle loading, and a 18,000 pound axle loading does three times as much damage as a 14,000 pound axle loading. Based on Table 1, it is possible to divide up the various axle loadings into classes upon which the weight-mileage fee could be based, and which would equitably charge heavy trucks for the damage and wear which they cause. Two possible fee structures are given in Table 2.

Several factors must be noted with respect to Table 2. One, trucks which carry heavy axle loads will be required to pay heavy user charges. Two, structure B is twice as expensive for each class than is structure A. Information and time constraints have prohibited us from calculating the "perfectly equitable" fee structure. Rather, structures A and B define a range of possible structures which we believe should be considered. We have shown earlier that heavy trucks pay only approximately $4 billion out of $22 billion in user fees and out of a total highway budget of over $31 billion. We estimate that trucks should pay approximately two to three times more than they are now paying, and accordingly, structure A is designed to raise approximately $4 billion and structure B approximately $8 billion. At this time, we recommend that structure A be selected to begin the program with the DOT cost allocation study utilized to make any changes, if necessary. Third, it must be noted that the maximum single axle loading classes go no higher than 18,000 pounds, while the current federal limit, which most states have adopted, is 20,000 pounds. We have concluded that because the majority of the interstate highway system, and almost all non-interstate highways and bridges, were designed for maximum single axle loadings of 18,000 pounds or less, and because the increase from 18,000 to 20,000 pounds has such a major impact on highway wear and life, the federal axle load limit should be reduced to 18,000 pounds.

The individual states would still retain primary responsibility for highway maintenance, would still set state fuel taxes and registration fees, would be responsible for enforcement, could set lower vehicle weight and size limits and could set additional user fees. We believe they would cooperate in a nationwide weight-mileage fee program. Many states have already recognized

Table 1

Equivalent 18,000 Pounds Single-Axle Load Application Factors For Varying Single Axle Loads (Based on AASHO Road Test Equations).32/

Load (pounds)	Load Application Factor
8,000	0.03
10,000	0.08
12,000	0.18
14,000	0.34
16,000	0.60
18,000	1.00
20,000	1.57
22,000	2.37
24,000	3.45
26,000	4.88
28,000	6.73
30,000	9.09

Table 2

Two Possible Weight-Mileage Fee Structures

	Maximum Single Axle Loading Classes (Pounds)				
	≤10,000	10-12,000	12-14,000	14-16,000	16-18,000
A(mills/ton-mile)	0.7	2.0	4.0	7.0	12.0
B(mills/ton-mile)	1.4	4.0	8.0	14.0	24.0

the need for weight-mileage fees and many more will undoubtedly do so in the near future.

Congress has recognized the need for a thorough analysis of the highway financing process and, accordingly, mandated a comprehensive highway cost allocation study in the Surface Transportation Assistance Act of 1978. Because of its complexity, the final report is not due until January 15, 1982.33/ Because of the growing crisis in highway finance and the need to equalize governmental treatment of rail and truck freight, we believe it is imperative to institute a nationwide weight-mileage fee program as soon as possible, with the above DOT report serving to refine the program if necessary.

Thus, it is strongly urged that action be taken immediately to set up a nationwide weight-mileage fee program. While we feel it must be coordinated by the federal government, maximum state involvement in the final design and operation of the program should be encouraged. Any necessary refinements will be possible after the conclusion of the DOT cost allocation study.

C. Elimination of Property Taxes on Railroad Rights-of-Way

1. Options

This initiative can be implemented in many ways. The government could exempt railroads from payment of property taxes, it could reimburse them for such payments, or it could "nationalize" their land and long term lease (100 years) it back for a negligible fee with no strings attached. It is questionable whether the federal government could legally accomplish the first option, such matters would probably be up to the states individually, and attempts to force them to comply might be unconstitutional. Direct reimbursement for these payments would burden the government with a debt and would likely be politically unpopular (as would the first option). It could also be seen as enriching the private owners of the railroads.

The last option has perhaps the most viability and potential benefits of the three. It would involve extending an option to each railroad company to yield ownership of their rights-of-way to the federal government, with the government leasing the property back to the companies. The leases would be long-term (on the order of 100 years) and inexpensive, and would have no strings attached. Acceptance of this option would eliminate property tax payments since the federal government is not liable for property taxes.

The federal government would not offer to pay the rail companies for the rights-of-way, rather it would offer to assume ownership. The benefit to the rail company would be zero property taxes, the drawback would be that it no longer would be the absolute owner. But since the lease-back mechanism would be long-term and would involve only a token fee (for example, $1 per year), it would seem that the railroad companies would have little to lose.

2. Implementation

The bill allowing government "nationalization" of railroad rights-of-way would include the following provisions:

1) Railroads would be given the option of transferring ownership to the federal government.

2) Railroads would have the right to lease back from the government any and all rights-of-way that they transferred to the government, for long periods of time for a token fee.

3) The government could allow any railroad company to lease rights-of-way not claimed by the original owner, but the original owner would have the right of first refusal.

D. Summary of Implementation Options

It is now clear that our program to eliminate the governmental subsidy differential between truck freight and rail freight, in an attempt to encourage the use of more efficient rail transport, involves three components:

1. A short-term federal grant program to allow the railroads to "rebuild" much of their fixed plant.

2. The enactment of a nationwide weight-mileage fee program for freight trucks.

3. The offer by the federal government, as an option to each railroad company, to nationalize rail rights-of-way with inexpensive, long-term leasing back to the railroads with no-strings attached.

Implementation Cost

Clearly, the major cost to the government of the program discussed above would be the direct subsidy program designed to modernize the rail system and to make it more attractive for freight shippers. We estimate these grants to be in the range of $5 to 20 billion which would certainly be a major new cost to the federal government. Because of the time and supply constraints of the modernization program, these grants could be spread over a five year period which would dilute the economic impact on the federal budget. The magnitude of these grants does not seem unacceptable in view of the annual $30 billion plus highway budget.

The other two parts of the program, the nationwide weight-mileage fee and the optional nationalization of rail rights-of-way with long-term lease-back to the rail companies, are not expected to involve significant cost or investment for the federal government. As mentioned earlier, Oregon's weight-mileage fee uses only 2.5 to 3.0 percent of its total revenues for administrative purposes. The optional nationalization program, since it involves no significant transfer of funds at any time, should require only a very small number of people to oversee it.

Assuming that by 1990 the federal grant program had cost $20 billion, that five years of the nation wide weight-mileage fee program produced $20 billion in revenues, and that five years of nationalized rail rights-of-way cost $2.25 billion; then the 18.4 billion gallons of fuel saved through 1990 would be at a "cost" of 12 cents/gallon. Of course, beyond 1990, the increased weight-mileage fee would become the source of significant additional government revenues while resulting in continuously growing fuel savings.

Supply of New Technology

It should be readily apparent that little or no new technology is required for our recommended program. More critical will be the availability of the specialized equipment and materials to modernize the railroads, such as new track, locomotives, cars, etc. As discussed earlier, the modernization process will take time and we believe the requisite hardware can be made available over a five-year period.

Impacts

1. On State & Local Property Tax Receipts:

Railroads accounted for 0.8 percent of total property tax revenues in 1976, 34/ ($451 million out of a total of $57 billion). A loss of this money would certainly not affect state governments significantly, since property taxes are only a minor source of revenue for them. On the other hand, certain local governments may be affected more severely. It is expected that these areas will be few, however.

2. On the Trucking Industry:

Because of the slow shift in modes foreseen, the initiatives are not likely to have significant adverse effects on the trucking industry. We hypothesized above that the trucking industry would stabilize at approximately current levels, the loss to rail would be the growth that would otherwise be expected in the trucking industry. Its market share will decrease, but its volume is not likely to drop. This should not cause great hardship on the trucking industry.

The nationwide weight-mileage fee on heavy trucks will clearly provide an additional major expense for freight trucks, and will contribute to the slow shift to rail hypothesized above. Truck owners may find their total user fees doubling. But it must be recognized by the trucking industry that such a fee system is the only equitable way to maintain the highway system, upon which it is completely dependent.

3. On Railroads:

The initial infusion of funds from the grants by the federal government will allow the railroads to perform long-deferred maintenance. The money will not necessarily be enough to complete this task, but it will certainly go a long way. The total of all deferred maintenance and capital investments on railroads is in the range of $5-$20 billion. Once brought up to date, it is estimated that the system could be maintained for around $3.6 billion annually. (Current expenditures are about $2.4 billion).35/ As mentioned earlier these grants would be contingent on the condition that the railroads spend all of the money on track and road bed improvements, in addition to the money they would have reinvested from their own revenues (based on past expenditures). Thus, the railroads' short-term profitability would not change.

The imposition of weight-mileage fees on heavy trucks would not have any immediate direct impact on the railroads, but would, over a period of time, allow rail to compete on a more equal footing with trucks and thus probably would allow rail to recapture some of its lost markets. Similarly, the optional nationalization with no-strings lease-back to the railroads would benefit the rail companies because they would no longer be responsible for state and local property taxes, but there would likely be no other major impacts of the nationalization program on the railroads.

4. On the Economy:

The general effect of the initiatives is to put trucks and railroads on an equal competitive footing. On the one hand, the public must pay for the federal grants to the railroads, but on the other hand they will be subsidizing truckers' use of highways to a much lesser extent. This trade-off can only benefit the economy in the long run, since it encourages the use of efficient modes of transport and restores competition between truck and rail.

5. On the Environment:

Railroads pollute much less than trucks moving the same amount of freight, mainly because they use only one-quarter the amount of fuel that trucks do. They also contribute less noise pollution than trucks as a whole, since one freight train can carry the load of hundreds of trucks. Railroad tracks are also less likely to be situated near residential areas than highways.

6. On Safety:

Highway safety is a critical issue with respect to heavy trucks. Traffic accidents involving heavy trucks (greater than

26,000 pounds) killed an estimated 4,624 people in 1978, a 40 percent increase since 1975.36/ In accidents between passenger cars and heavy trucks, the passenger car occupant is much more likely to suffer a severe injury or death regardless of who is at fault. Thus, there is an important equity problem in such accidents. And the situation will doubtlessly worsen as passenger vehicles become smaller and lighter while trucks (in some states) have been allowed to become longer and heavier.

Based on the growth expected in the freight trucking industry (barring policies encouraging a shift to other modes) and the factors mentioned above, it does not seem unreasonable to predict that 8,000 or 9,000 people might die each year by 2000 in accidents involving heavy freight trucks if no major actions are taken. If our assumption that this initiative will stabilize intercity trucking levels at current levels is valid, it could save between 3,000 and 5,000 lives a year by the year 2000. It should go without saying that this impact is a critical benefit of this initiative. Highway safety would be greatly improved by reducing the number of heavy freight trucks on the highways.

7. On the Need for Imported Material:

The initiatives would of course conserve fuel, which is a major import. Metals used in truck manufacturing would also be conserved. Rail cars generally have much larger lifetimes than trucks do, so increased production of freight cars would not erase this benefit.

Overall, these initiatives would have very beneficial impacts on most sectors of the economy, and on societal goals. They should be implemented as soon as possible so full advantage can be taken of these benefits.

Recommendations

Our recommendations include one program to "compensate" the railroad industry for the inequitable governmental subsidy differential with which it has suffered from in the past, and two programs to eliminate the subsidy differential in the future. The recommended actions are:

1. A five-year, $5-20 billion federal grant program to permit the railroads to modernize their tracks and road bed.

2. The enactment of a nationwide weight-mileage fee program for freight trucks based on gross vehicle weight, maximum axle loading and mileage as indicated in Structure A of Table 2. It is estimated that the recommended program would approximately double the $4 billion in user charges now paid by heavy trucks.

3. The offer by the federal government, as an option to each railroad company, to nationalize rail rights-of-way with no-cost, long-term leasing back to the railroads with no-strings attached.

References

1/ See, among others, David J. Stein, "Public Ownership of Rail Rights of Way, Public Financing, Private Sector Operations, and the Public Interest," Proceedings, Transportation Research Forum, 1977 (hereafter "Public Ownership . . ").

2/ Transportation Energy Conservation Data Book, Edition 3, Oak Ridge National Laboratory - 5493, February 1979, p. 1-18 (hereafter "Data Book").

3/ "Data Book", p. 1-18.

4/ The Rail Industry and the Growing Crisis in Highway Finance, by L. Lee Lane, Association of American Railroads, Feb. 16, 1980 (hereafter "The Rail Industry. . .").

5/ "Data Book", p. 1-18.

6/ Alternative Fuels and Intercity Trucking, Prepared by Ryder Program in Transportation, U of Miami, and Escher Technology Associates, St. John's, Michigan for DOE, HCP/M3294-01, June 1978, p. 37.

7/ "The Rail Industry. . ." p. 3.

8/ Projections of Direct Energy Consumption by Mode 1975-2000 Baseline, by Rita Knorr and Marianne Millar, Argonne National Laboratory/CNSV-4, August 1979, pp. 4, 86, and 96 (hereafter "Projections 1975-2000").

9/ Yearbook of Railroad Facts, Association of American Railroads, 1979.

10/ National Transportation Policies Through the Year 2000, National Transportation Policy Study Commission Final Report, June 1979, p. 323. (hereafter "National Transportation Policies...").

11/ "National Transportation Policies...", p. 324.

12/ "National Transportation Policies...", p. 173.

13/ "The Rail Industry . . ." p. 4.

14/ MVMA Motor Vehicle Facts and Figures, '79, p. 89.

References (cont'd)

15/ "The Rail Industry . . ." p. 5.

16/ "A Study of Road Damage as a Result of Truck Weight," Lloyd R. Jennings, The Police Chief, January 1979, p. 42 (hereafter "A Study of Road Damage").

17/ Allocation of Highway Cost Responsibility and Tax Payments, 1969, Bureau of Public Roads, FHWA, DOT, May 1970, pp. 12, 74.

18/ "A Study of Road Damage...," p. 42.

19/ Testimony of John D. Kramer, Illinois Secretary of Transportation, before the U.S. DOT Truck Size and Weight Study Public Meeting in Chicago, Illinois, July 13, 1979, p. 1.

20/ "The State Perspective on Highway Tax Design", Loyd Henion, Oregon Department of Transportation, October 30, 1979, p. 11 (hereafter "The State Perspective. . .").

21/ "A Study of Road Damage. . .," p. 42.

22/ MVMA Motor Vehicle Facts and Figures, 1979, p. 87.

23/ "The Rail Industry. . ." p. 6.

24/ "Increased Truck Size and Weight, The Impact on Highways, Safety, and Energy," Central States Resource Center, March 1980, p. 10 (hereafter "Increased Truck Size...").

25/ "The Rail Industry . . ." p. 7.

26/ "Data Book," p. 2-27.

27/ "Projections 1975-2000," p. 85.

28/ "Public Ownership . . .," p. 353.

29/ "The State Perspective..."p. 7.

30/ Statement of Fred L. Smith, Jr., Association of American Railroads, before the Maryland Senate Budget and Taxation Committee, January 28, 1980, p. 7.

References (cont'd)

31/ "The Rail Industry . . ." p. 8.

32/ "Increased Truck Size . . .," p. 8.

33/ Statement of John Clements, American Association of State Highway and Transportation Officials, before the Senate Committee on Commerce, Science and Transportation, Sept. 6, 1979, pp. 3-4.

34/ Statistical Abstract of the U.S., 1978, Bureau of the Census.

35/ Government Ownership of Railroad Fixed Plant. AAR Staff Studies Group, Working Memorandum 74-10. October 1974, p. 7.

36/ "Increased Truck Size . . .," p. 19.

An Initiative to Encourage Urban Transit System Modernization and Expansion

Summary

Although significant urban fuel savings can be obtained when urban automobile users shift to more fuel efficient modes of transportation, the magnitude of these savings tends to be roughly proportional to the size of the transit system. Therefore, it is proposed as a fuel saving initiative that the existing program under the Urban Mass Transportation Act (UMTA) of Federal capital and operating expense subsidies be revised to provide stronger incentives for the local expansion and improvement of urban mass transit service. The new UMTA program should involve rewards rather than subsidies in the disbursement of UMTA funds to local transit authorities. Under the new program Federal mass transit support would be prorated entirely (no strings attached) on the number of passenger-miles accumulated by the system during the proceeding year.

Transit authorities able to demonstrate increased ridership would receive increased (relative to current levels) capital and operating funds to support their programs while, conversely, ridership decreases would result in decreased funding. Presumably the total Federal subsidy would still be determined by Congress. The magnitude of the overall subsidy could be adjusted to provide continuity with pre-amendment funding levels in order to minimize initial dislocations.

The rationale for these revisions is that under UMTA's present subsidization approach, urban mass transit has become a less rather than a more significant form of urban transportation in spite of the obvious fuel and cost economies favoring bus transit systems. The protection from competition which municipal transit franchises enjoy and the steadily increasing public subsidies together provide little local incentive for innovation and cost control in the transit industry. The current system tends to reward failure rather than success, a result which is in part due to the lack of local flexibility and resulting lack of initiative associated with the present program. Therefore, these are the factors addressed most directly by this "last chance" change in the mass transit assistance program.

In fiscal year 1980, the total of both the discretionary and the formula, capital and operating funds which are authorized for urban mass transit is $2,785,000,000.13/ Thus, if 6,500,000,000 revenue passengers travel an average of 6.0 miles14/ each in 1980, the national average prorated value for urban transit support would be $0.071 per passenger-mile or about $0.43 per passenger-trip. At its current size urban transit can induce at most an approximately one percent reduction in the fuel used for urban transportation or approximately 32,000 barrels per day. If the urban transit system could be expanded to carry about 20 percent of urban trips, reduc-

tion in urban fuel usage on the order of 8 percent or 250,000 barrels of urban automotive fuel per day.

If it is assumed that the initial 32,000 barrels per day fuel savings can be obtained by increasing the load factor on existing buses (no increase in the number of buses or bus-miles) and that the average automobile displaced had been obtaining 14 mpg (over an average trip length of 6.0 miles) and carried an average of 1.4 persons, then the Federal "cost" per gallon of fuel saved is $1.30.

If it is assumed that additional expansion requires more bus-miles and that only 3/4 of the fuel that can be saved through increased load factors can be saved when more bus-miles are necessary, the Federal "cost" per gallon of fuel saved is $1.73.

Since this initiative involves initially a redistribution rather than a change in UMTA funding, the total cost will at least initially remain at current levels. As the initiative starts to work and mass transit expands, the Federal "costs" will go up. If the full potential of saving 32,000 barrels per day of fuel is realized, then a 22 percent increase in mass transit passenger-miles will result - increasing the current cost of $2.785 billion by $0.61 billion.

Background

Current policy considerations regarding energy conservation and production independence, as well as requirements of the Clean Air Act regarding attainment of ambient air quality standards have pointed to the development of improved public transportation services as a key program element. Such expansions of transit service hold the promise of reductions in both air pollutant emissions and transportation energy consumption. Comparisons of typical auto and transit air pollution and energy consumption characteristics indicate the relative attractiveness of transit.1/

Estimates such as those by Mittal3/ of the relative fuel consumption of various transportation modes frequently employ the concept of "energy intensiveness," the fuel energy required per passenger mile of service. Thus, for the national average automobile which in 1980 will have an urban fuel economy of approximately 13.3 mpg2/ and carry an average of about 1.7 passengers during urban trips (or 1.4 passengers during commuting trips),13/ the energy intensiveness (EI) would be:

$$\text{EI(average auto)} = 115{,}000(\text{Btu/gal})/(13.3 \text{ mpg} \times 1.7 \text{ pass})$$

$$= 5{,}090 \text{ Btu/pass-mi}$$

Mittal's estimates for urban bus energy intensity are:

Vehicle Type (no. seats)	Btu per Vehicle-mi	Fuel Economy (mpg)
Diesel Bus (50)	31,000	4.1
Medium Bus (30)	28,000	4.5
Mini-Bus (24)	17,000	7.5
Van (11)	13,300	9.5
School Bus (50)	16,400	7.7

Therefore, a medium size bus which is carrying a typical peak period load of 24 passengers has an energy intensity of only 1167 BTU/pass-mi. and can equal, on this basis, the energy intensity of the average automobile carrying 5 or 6 passengers.

Obviously, if a significant number of automobile drivers who drive alone can be persuaded to shift to more energy efficient modes of urban transit, there is a potential for a large decrease in the amount of fuel used for intra-urban travel.

Practically, this potential will not be achieved easily. Our urban mass transit system has suffered from years of neglect. Cheap fuel, a broad and expanding network of public highways, and massive shifts since World War II in urban population densities have deemphasized transit use until today in most cities it is used by only about 3 percent of urban travelers.4/

This decay in the relative number of trips by transit has continued in spite of massive subsidies under the Urban Mass Transportation Act of 1964 (UMTA). Presently, local transit authorities are subsidized by UMTA to the extent of 80 percent of their new capital and up to 50 percent of their operating expenditures. By 1980, annual UMTA disbursements will have increased to $2,875,000,000; and there is no guarantee that this will prove sufficient even to save urban transit much less significant amounts of fuel.5/ If this trend, the decay of urban transit systems, is to be reversed, strong and effective measures will have to be applied consistently to persuade significant numbers of travelers to shift from their automobiles to bus transit.

The basic problem with the 1964 UMTA appears to be an underestimation of the magnitude of the effort required to provide a real urban transportation alternate to the private automobile. Even now, the actual, as opposed to the potential, effectiveness of new public transportation services in providing major energy savings has, for the most part, not been well established. Much of the early reported research dealt, as we did above, with variations in the energy use and the air pollutant emission characteristics of alternative transportation systems under assumed or empirically "average" conditions. These studies tend to be overoptimistic with respect to both the costs and fuel savings attributable to new transit system investments. It is generally agreed that this use of average conditions has significantly distorted the analyses of transit energy consumption and air pollution.

Recent studies have tended to be pessimistic. According to Hirst, the short-term energy conservation potential of increased mass transit is small because of the small size of the present transit industry and because of the small fraction of urban passenger transportation carried by bus.4/ Recent EPA sponsored studies concluded that new or improved transit services may have a distinctly negative impact on fuel consumption unless a majority of the new transit passengers were previously automobile users.6/7/ It is very important that the various fuel conservation initiatives in the area of urban transportation be considered very carefully both with respect to their short and long-term effects.

EPA, DOE, and DOT have each sponsored studies of the methods and results of transportation control policies to reduce automobile use. One of the most detailed methodologies was developed for DOE by Cambridge Systematics, Inc. (CSI).8/9/ Their disaggregate approach uses a variety of submodels and local interviews to predict the effects of transportation related policies on both work and nonwork related auto, transit, and carpool trips and on areawide fuel consumption and air pollution. In addition to the direct effects of travel mode shifts, this method addresses the extent to which increases in the trip circuitry and the vehicle weight associated with carpooling influence overall fuel consumption. Other questions treated include what happens to vehicles left at home, how the increase in non-work related trips is affected by vehicle availability, and how various economic and social groups are affected by the shifts. When good data are available, the model is highly predictive of short term results.10/ No method has been developed which successfully predicts long-term effects of transportation policy, e.g., land use trend rates.11/

The following lists and briefly describes the more significant automobile-to-transit mode shift policies that have been studied by CSI and other analysts.

Automobile to Urban Transit Shift Initiatives

Expansion of transit fleets:

- Existing transit systems do not have the capacity to achieve large scale reductions in auto use.4/

- A 10 to 20 percent reduction in urban auto use may require bus fleet expansions of at least 50 to 500 percent.1/

Free or reduced transit fares:

- This policy mainly affects commuters who are already inclined toward urban transit use.6/

- Most of the new transit trips generated this way wouldn't have been made by automobile anyway.6/

Automobile user charges:

- "Free" highways and subsidized parking underprice automobile use and impose a significant cost disadvantage on transit from the traveller's point of view. Approximately 70 percent of the highway funds come from various user charges, e.g., gasoline taxes, which are not currently available to local transit authorities.11/ Higher gasoline taxes, regional road use taxes, and local parking permit taxes or price increases are all effective ways of reducing fuel consumption.

- Increases in fuel prices affect non-work travel much more than they do work related travel.9/

Parking restrictions:

- Parking restrictions should be used to encourage urban transit use and to discourage all day commuter parking. They are only effective if more efficient alternatives to the singly occupied auto are available, and are best applied on an areawide basis.6/ Unlike parking taxes, parking restrictions generate no new income.

Priority treatment for high occupancy vehicles:

- The convenience, speed, and reliability of bus service can be substantially increased by allocating special highway lanes to high occupancy vehicles. Priority treatment can increase average bus freeway speeds by a factor of two without significantly effecting auto speeds, and surface street speeds up to 50 percent. In comparison to automobiles, buses can carry 2 to 3 times more people per hour on surface streets and 10 to 20 times more people per hour on freeways.

Improvement of transit route structures:

- Most urban area commuter trips originate or terminate in the suburbs. Most urban transit systems are central business district oriented and, therefore, serve suburban areas rather poorly. Since all studies of fuel conservation by urban transportation mode shifting agree that the only significant fuel savings will come with the elimination of single occupancy automobiles, the diversion of these suburban commuters to transit travel is most important.

All of the above methods have been used to modify transportation patterns and to varying degrees they all work. Because of the limited capacity of present transit systems and because the magnitudes of the decrease in fuel consumption achieved by mode shifting depend strongly on the method used to induce the shift, however, the selected policy must be optimized with respect to existing local transit system realities and fuel savings potential. Therefore, the local transit authorities are in the best position to institute mode shifts, if they can be sufficiently motivated to do so.

Many of the above policies have been studied by CSI who have applied their methodology to the transit systems and populations of Denver, Fort Worth, and San Francisco. One of the strongest results of their study is the significant dependence of bus related effects on the proportion of urban trips made by transit. The predicted change in fuel consumption, the decrease in single occupancy vehicle traffic, and the change in the size of the transit ridership all show strong correlations with transit's share of the urban transportation base, T_o. For example, data obtained from CSI's Tables III-2 through III-9, corresponding to the effects expected from a policy of priority bus lanes, which gives a 25 percent reduction in bus transportation headway, have been plotted against T_o in Figure 1.9/ Obviously, the fit is very good.

If the urban fuel savings corresponding to CSI's other bus related mode shifting policies are plotted in a similar manner, as shown in Figure 2, it is seen that the fuel savings that can be reasonably expected from existing urban transit systems which serve only 3 or 4 percent of the urban ridership range from about 0.1 to at most 2.0 percent.

If the national average for urban trips made by bus transit were on the order of 15 to 20 percent of the total, fuel savings approaching 8 percent would be possible. It is important to understand that the real benefits of a reemphasis on urban and inter-city transit systems will come in the future. According to Hirst, "changes in urban travel patterns are likely to require at least a decade because of long lags associated with changes in land use patterns, auto ownership, and individual attitudes toward public transportation. Thus, unless improvement projects are undertaken now, the long-term potential benefits of mass transit will never be realized. Also, mass transit offers other benefits besides reduced energy use: less congestion during peak periods, fewer traffic fatalities, and increased mobility for those with limited access to autos."4/

In summary, there are many policies by which state or local governments or their agencies can induce fuel savings through urban transportation mode shifts. These range from decreasing fares to increasing fuel prices and include gasoline rationing or restrictions on the availability of gasoline. In each case the effectiveness of the policy with respect to fuel consumption will be determined mainly by the size of the transit systems.

Therefore, the most effective fuel saving initiative in the area of urban transportation is one which provides for the consis-

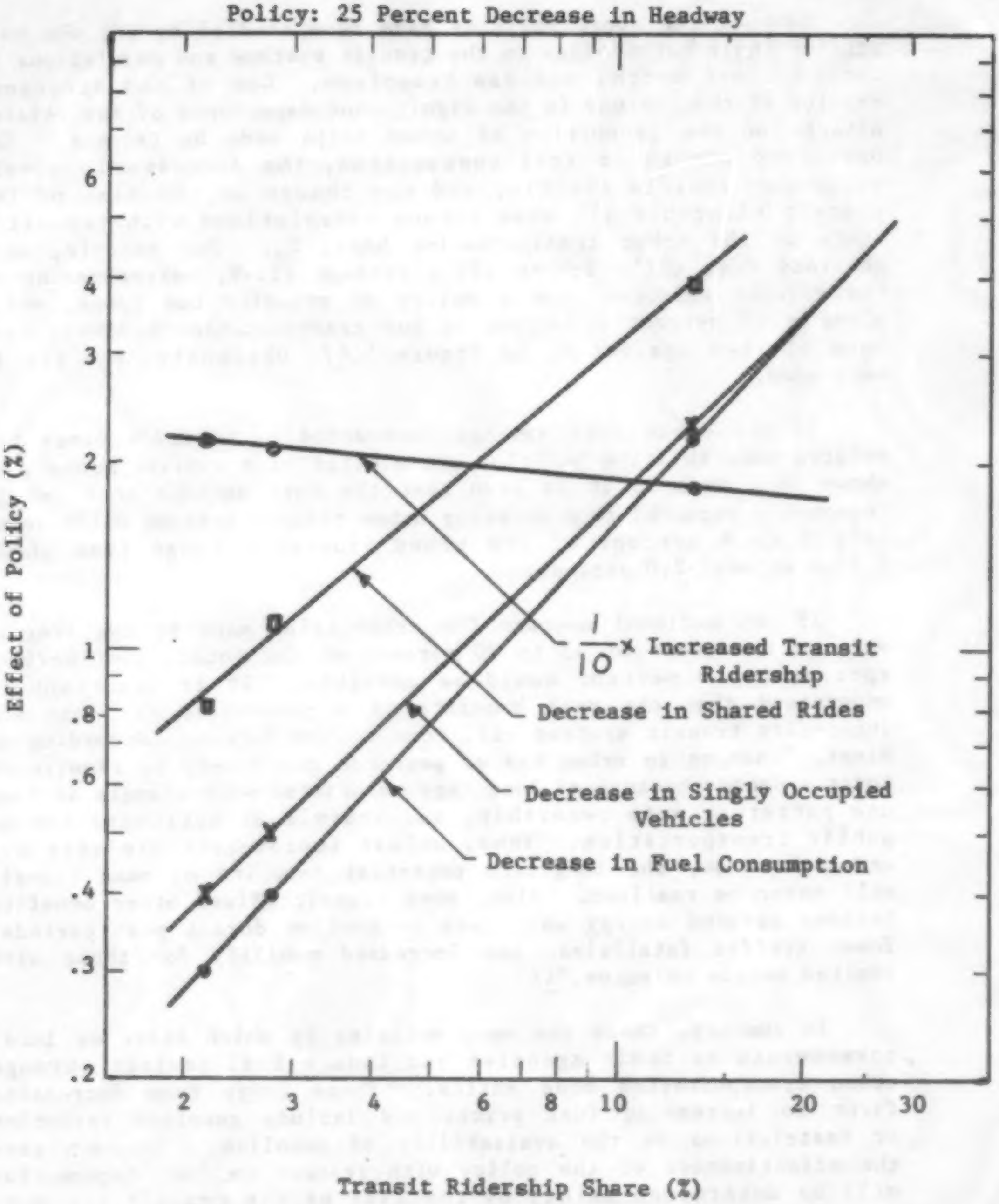


Figure 1. Plots Illustrating the Dependences of Fuel Conservation Related Factors on Transit Size (CSI data)

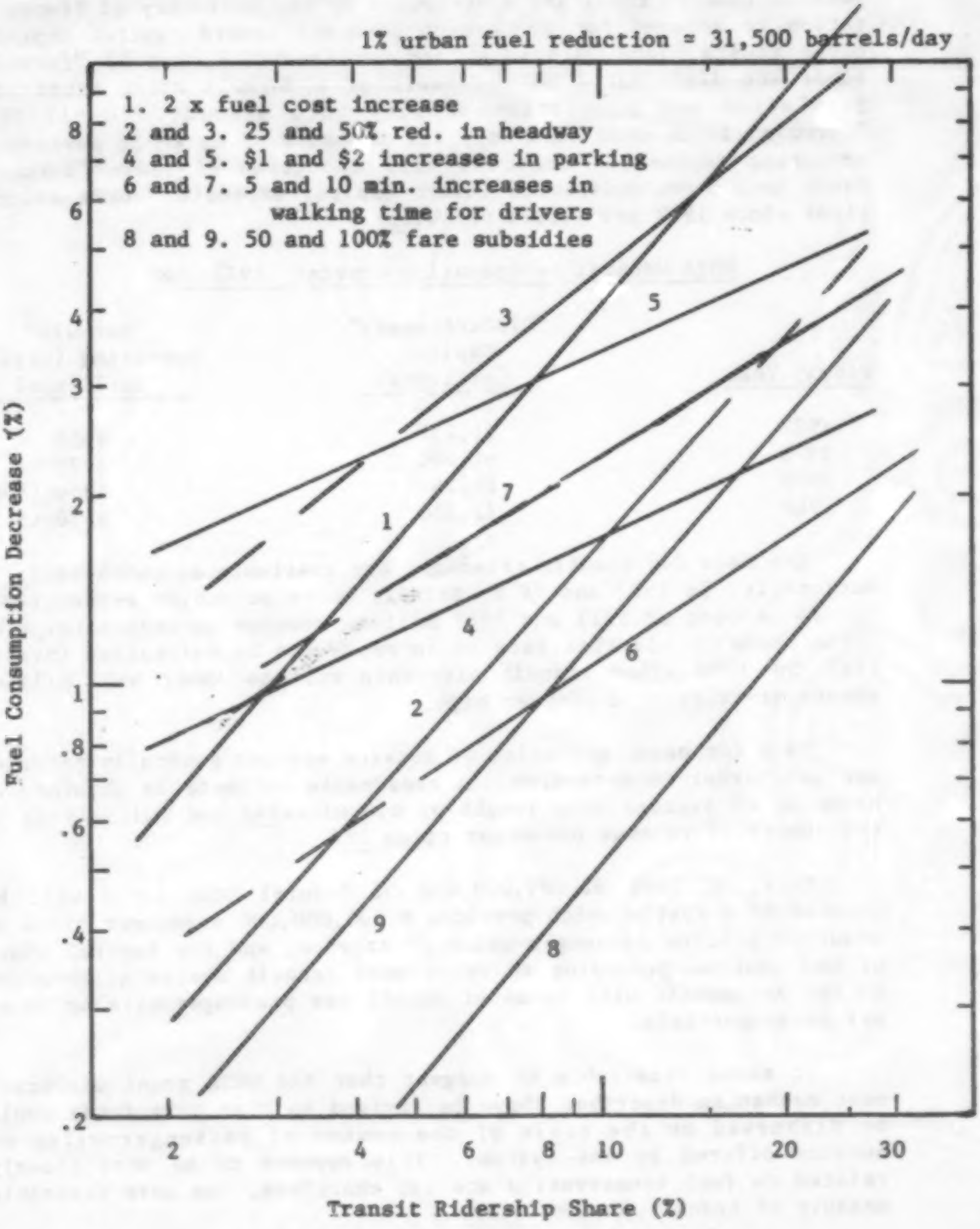


Figure 2. Summary of Estimated Effects of Various Transportation Mode Shifting Policies on Fuel Consumption (based on CSI data)

tent, long-term growth of urban transit systems.

Currently, UMTA grants are distributed in two ways: 1) "discretionary" funds are distributed by the Secretary of Transportation to be used for 80 percent payments toward capital expenditures (buses, land, stations, and construction), and 2) "formula" funds are distributed on the basis of a formula which takes both population and population density into account. Until 1978 "formula" funds were used only for payments of up to 50 percent of operating expenses. Since FY 1979 a portion of these "formula" funds have been redirected toward capital expenses. UMTA allocations since 1977 are listed below.13/

UMTA Capital on Operating Grants: 1977-1980

Fiscal Year	"Discretionary" Capital (millions)	"Formula" Operating (Capital) (millions)
1977	$1,250	$650
1978	$1,400	$775
1979	$1,250	$850 (580)
1980	$1,380	$850 (555)

The data for transit ridership are available up until 1978.14/ Nationally, in 1977 and 1978, transit buses accounted respectively for 74 percent of 5723 and 5967 million revenue passenger trips by urban transit. If this rate of increase can be maintained through 1980 the 1980 urban transit ridership will be about 6500 million passenger-trips -- a 10-year high.

Data for passenger-miles of service are not generally reported and are harder to determine. A reasonable estimate is obtained by assuming an average trip length of 6.0 miles14/ and multiplying by the number of revenue passenger trips.11/

Thus, in 1980 $2,785,000,000 of federal UMTA funds will be granted to a system which provides 6,500,000,000 passenger rides or about 39 billion passenger-miles of service, and the Federal share of the cost of providing an urban mass transit system alternative to the automobile will be about $0.071 per passenger-mile or $0.43 per passenger-trip.

It seems reasonable to suggest that the UMTA grant disbursement mechanism described above be revised so that UMTA funds would be disbursed on the basis of the number of passenger-miles of service offered by the system. This appears to be more closely related to fuel conservation and is, therefore, the more desirable measure of transit productivity.

Another approach would be to apply a transit expansion reward factor on top of the existing awards procedure. The magnitude of the expansion reward would be proportional to the percentage increase in transit ridership.

Fuel Conservation Potential

This initiative -- to establish financial incentives which reward local transit authorities who increase their share of the urban transportation load -- will take several years to reach its full potential. The achievement of even two or four fold increases, over the next five years, in the size of the transit fleet will require 15 and 32 percent yearly net expansion, respectively.

If in the light of present trends, a 20 percent yearly expansion rate is targeted and ridership increases obtained through, for example, 25 percent reductions in headway through improvements in local traffic patterns and the introduction of priority traffic lanes for high occupancy vehicles, then according to Figure 1 urban fuel savings on the order of 0.4 percent initially will increase after five years to about 1.5 percent per day of the total urban passenger transportation fuel consumption.

On a percentage basis these appear to be small gains: the national transit fleet is small, but nationally a 1.0 percent reduction in the urban use of petroleum fuel corresponds to an 0.58 percent decrease in the total fuel consumed (81.7 million gallons in 1977) for passenger transportation.12/ Thus, a one percent reduction in the fuel consumed for urban transportation is equivalent to 475 million gallons of fuel per year or about 31,500 barrels of automotive fuel per day.

Costs to Implement

The direct costs of the initiative for the transit operators are those associated with measuring the performance in passenger-miles of each urban transit system. Under the new section 15 of the Urban Mass Transportation Act local transit authorities are required to provide passenger-mile and various other kind of performance oriented data. Depending on the accuracy desired, passenger counting machines which are currently being tested may have to be purchased. Alternately, passenger-mile data could be based on occasional surveys of average transit trip length and yearly passenger loads.

If it is assumed that the initial 32,000 barrels per day fuel savings can be obtained by increasing the load factor on existing buses (i.e., no increase in the number of buses or bus-miles) and that the average automobile displaced had been obtaining 14 mpg (over an average trip length of 6.0 miles) and carried an average of 1.4 persons, then the Federal "cost" per gallon of fuel saved is $1.30.

If it is assumed that additional expansion requires more bus-miles and that only 3/4 of the fuel that can be saved through increased load factors can be saved when more bus-miles are necessary, the the Federal "cost" per gallon of fuel saved is $1.73.

Since this initiative involves initially a redistribution rather than a change of UMTA funding, the total cost will at least initially remain at current levels. As the initiative starts to work and mass transit expands, the Federal "costs" will go up. If the full potential of saving 32,000 barrels per day of fuel is realized, then a 22 percent increase in mass transit passenger-miles will result - increasing the current cost of $2.785 billion by $0.61 billion.

Supply

The question of the difficulty of increasing the size of the transit fleet fast enough has been raised.13/ In fact, however, the major obstacle to transit fleet expansion has been manufacturers' and transit authorities' uncertainties regarding future need. The added stability brought about by this initiative should provide more than adequate stimulus to new bus construction. At the same time the development of new more fuel efficient buses will also be stimulated. The rate of new motor bus introduction has been as high as 10.4 percent per year during the last decade. Recently, older buses have been retired at a rate of about 6 percent per year. Up until 1977 the actual average net growth of urban motor bus transit had been on the order of 0.5 to 0.75 percent per year.

If the current bus retirement rate continues, a 20 percent yearly expansion of the transit fleet would require yearly increases in new bus construction on the order of 25 percent. A recently introduced program to rehabilitate old buses15/ should bring the necessary transit fleet construction expansion rate down to an attainable 15 to 20 percent per year.

Impacts

The most obvious impact will be the reduction in the use and purchase of private automobiles as people shift at first occasionally and then on a more regular basis to urban transit. It seems likely, however, that these reductions will be gradual and take the form of a delay in the decision to purchase or a decision not to purchase new cars, since for the near future, at least, the possession and use of an automobile is still central to our way of living. In any case, some automobile oriented organizations will resist.

Impacts associated with reduced automobile use include: reductions in fuel consumption and exhaust emissions (excepting diesel particulates*), reduction in gasoline taxes and other highway user charges, increased auto safety, decreased traffic congestion, and the possible loss of jobs in the automotive industry. It is probable that many of these lost jobs will be compensated by new jobs created by the transit industry.

---

* Portland, Oregon transit authorities are exploring the possibility of refitting their diesel buses with gasoline engines to reduce particulate emissions.15/

Another impact of the initiative is its possible effect on elderly and handicapped passengers who now receive special care and handling. In some cases these special services are extremely expensive and divert transit facilities from truly urban mass transit service. From an energy conservation perspective such "special needs" groups can probably be more efficiently cared for by modes of transportation other than mass transit. Some can still ride the buses, some can use dial-a-ride, and all can use cabs. If this initiative revitalizes mass transit, then more routes will be served and access may even improve for special interest groups. Therefore, decisions as to what extent the mass transit system should accomodate special needs groups should be left to the local transit systems. Proposals to provide special transportation services to special needs groups should be considered by Congress on the basis of their own merits.

Other impacts such as the effect of increasing transit usage on land use trends, e.g., the possibilities of more compact and revitalized cities, are not predictable from present models.

Implementation Options

One obvious implementation option is to do nothing. Fuel prices are presently increasing so rapidly that it might be thought that automobile users would be shifting to urban transit wherever possible. But, apparently they are not. According to the American Public Transit Association, recent increases in ridership have occurred at a rate of only 5 percent per year -- in part perhaps because local transit authorities have not been able to respond quickly enough to the needs of automobile drivers feeling the dollar pinch.

The addition of performance factor incentives would make it much more likely that new innovative transit service alternatives would be made apparent to automobile users at just the time they were feeling the worst pressure from gasoline price increases.

Additional research focusing on the range and costs of the various transportation options available to individuals for commuting, shopping or other personal travel, might be helpful if it helps individuals identify more efficient transportation means.

Finally, no effort to implement this fuel saving initiative will be effective without widespread public appreciation of both the national need to save fuel and the significance, on a personal and national basis, of mass transit's contribution to this goal. Consumer information in the form of handouts, radio or video spot advertising, and news items about successful transit systems and users could be made available to local transit authorities. All studies seem to indicate that the coordination of perceived extra automobile costs with improved transit convenience is critical to the success of transportation mode shifting policies.

Recommendation

The Urban Mass Transportation Act should be amended by Congress so that federal funds would be distributed solely on the basis of the passenger-miles of service.

Studies should be undertaken to determine transit performance factors and to evaluate the effect of their use on the short and long-term futures of urban passenger transportation.

References

1/ J. Horowitz and S. Kuhrtz, "Transportation Controls to Reduce Automobile Use and Improve Air Quality in Cities," EPA-400/11-74-002, November 1974.

2/ EPA Report to Congress in Response to Section 404 of NECPA, "Passenger Car Fuel Economy," DRAFT. (Urban fuel economies extrapolated assuming: 1) 16 percent new car replacement rate and 2) urban fuel economy is about 0.87 of road fuel economy).

3/ R.K. Mittal, "Energy Intensity of Various Transportation Modes," in Transportation Research Record, 689, Transportation Research Board, 1978.

4/ E. Hirst, "Transportation Energy Conservation Policies," Science 192, 4234, p. 15, April 1976.

5/ Senate Bill 5.2015, "A bill to amend the Urban Transportation Act of 1964 and Title 23 of the United States Code."

6/ J.P. Curry of DeLeuw, Cather & Co., "Case Studies of Transit Energy and Air Pollution Impact," EPA-600/5-76-003, May 1976.

7/ TRW/DeLeuw, Cather & Co., "Travel Impacts of Fuel Shortage and Price Increase Conditions." Prepared for the U.S. Environmental Protection Agency, December 1974.

8/ T.J. Atherton and J.H. Suhrbier, "Urban Transportation Energy Conservation - Vol. II," DOE/PE/8628-1, September 1978.

9/ T.J. Atherton and J.H. Suhrbier, "Urban Transportation Energy Conservation - vol. III" DOE/PE/8628-1, September 1978.

10/ EPA Report to Congress, "Urban Transportation and Energy: The Potential Savings of Different Modes."

11/ C. Difiglio, DOE Tech, memo, "The Urban Transportation Sector: A Preliminary Energy Conservation Strategy Assessment," March 1979.

12/ Motor Vehicle Manufacturers Association, MVMA Motor Vehicle Fact and Figures '79.

13/ Department of Transportation, Office of Public Affairs, Washington, D.C.

14/ APTA, Transit Fact Book, 1978-79 edition.

15/ Department of Transportation, Office of Policy, Budget, and Program Development, Washington, D.C.

Encouraging Vanpooling*

Summary

This initiative proposes a more efficient use of transportation energy through the promotion of vanpooling. The goal of this initiative is to convert 10% of the commuters who live over 10 miles from their place of employment to vanpooling by 1985.

Vanpooling is a commuter transportation mode designed for persons whose residences and places of employment are geographically clustered. Members of the pool ride to and from work in a van. This van is driven and maintained by one of the members of the pool rather than an outside party. The other members of the pool support the cost of the operation. A typical current vanpool carries from 8 to 15 riders and travels 50 miles to and from work each day. Each van can save about 2300 gallons of gasoline each year as well as reduce the number of passenger cars in service.

Benefits to vanpool members include relaxed commuting and reduced costs of auto ownership and operation while still maintaining door-to-door service. Benefits to the general public include reduced energy consumption, less traffic congestion and improved environmental quality. Major impacts of increased vanpooling are generally positive although there would be a trend toward less revenue from gasoline taxes and a negative effect on automobile sales. If the goal of this initiative is realized, 1.6 million passenger cars could be replaced by 275,000 vans carrying 2.2 million passengers. At a typical vanpool fare, annual savings to these commuters would be over $2 billion while total VMT would drop 12 billion per year. Approximately 41,000 barrels of gasoline per day would be saved for a yearly total of 630 million gallons.

At the heart of this initiative is a strong economic incentive based on rewarding performance (ridership). An annual Federal tax credit/rebate would provide $100 per passenger for vanpools of more than 10 miles one-way distance. A vanpool with 12 riders would provide the owner/operator an economic incentive of $1200 per year. The incentive is in one package - it looks larger to prospective vanpool organizers, it is easier to administer and enforce against abuses, and it stimulates the owner/operator to work to attract riders and to solve problems (insurance, etc.) as efficiently as possible. The "cost" to the Federal government through the tax credit/rebate, if the goal of the initiative is realized, is about 220 million dollars per year or about 35¢ per gallon of fuel saved.

---

* As used herein, vanpooling may occur in a car, but is distinguished from the traditional definition of carpooling in that a single owner's vehicle is used.

Background

Since the end of World War I, American society has developed around the automobile. The automobile has profoundly influenced the location and decentralization of industries, the growth and redistribution of the urban population, residential concentrations and the dispersion of employees relative to their place of work. Over the past few decades, employers have chosen their work sites, and employees have chosen their residences on the basis of the range of the automobile. The planning of highway arteries and suburban and inter-urban transportation facilities has been directed toward increasing this range.

Total nonagricultural employment in the United States in 1975 was 80,377,000 with approximately 76% of those in urban and metropolitan areas. A complete picture of recent trends will not be available until the 1980 census, but comparisons of 1970 census work-trip data indicate that there was a loss of over 1 million jobs in the central cities of the 12 largest Standard Metropolitan Statistical Areas between 1960 and 1970, and a gain of almost 600,000 jobs in the medium-to-large SMSAs. During the same time period, jobs outside the central cities increased by 6 million. Over half of today's jobs are located around the fringe of major urban areas. One of the most significant results of this trend to suburbanization is an increase in the home-to-work trip distance for commuters. The percentage of SMSA workers living over 10 miles from their place of work has increased from 23% in 1963 to 27% in the 1969-70 period.1/ More recent figures show that 35% of the home-to-work trips in metropolitan areas are over 10 miles with 87% of these within the 10-29 mile range.2/

As a result, the automobile has become a fixture of American society in general, and for transportation-to-work in particular. Recent studies have revealed that people are willing to pay more money for the convenience of using their car. A survey conducted for the Federal Energy Administration (FEA) in April, 1975 by the Opinion Research Corporation indicated that if people had to drive less, 80% of the public preferred to reduce pleasure driving rather than non-pleasure driving such as to-and-from work.3/ Such findings afford some understanding of the nature and level of the public's resistance to give up the automobile as the major mode of transportation to work.

About three-fourths of the private cars used for commuting to work are occupied by only the driver. Nonetheless, the remaining one-quarter of private cars used for commuting to work carry one or more passengers and account for almost half of all those who travel to work in private cars. The average number of people per commuter car is 1.4 and one-third of all gasoline consumed in the United States is travel to-and-from work.4/ Moreover, almost three-fourths of this is used by the 35% of workers who live over 10 miles from their place of employment.2/

There are a great number of locations where vanpooling programs could become effective. There are about 400 U.S. cities which are over 50,000 population and 250 SMSAs over 100,000 population. Within these boundaries, there are clusters of businesses and residential areas which could be properly served by vanpooling. In addition, large single businesses located outside these boundaries could also support vanpooling programs by themselves. The top 500 industrial firms employ over 15 million people, which is approximately 18% of the work force. The top 500 retailers employ about 3 million.5/ Almost all of these are employed in the U.S. Although such companies have a number of separate operations, most of these can be expected to be of a size and location which would lend themselves to vanpooling.

Based on the facts above it is clear that vanpooling has a great potential for savings in nationwide requirements of transportation energy.

Vanpooling is a direct descendant of carpooling, having its origins in the private sector. The 3M Company of St. Paul, Minnesota is credited with sponsoring the first employer-based commuter vanpool program. Since it began in early 1973, this program expanded to over 90 vans carrying approximately 10% of the employees centered at the 3M's St. Paul facility. The number of vanpools nationwide have almost doubled each year since the 3M Company developed the concept. There are now several hundred sites nationwide. These programs now have 12,000 vans serving over 120,000 commuters. An organization known as the National Association of Vanpool Operators was formed in 1976 and now claims 300 dues-paying members. Its stated objective is the growth of vanpooling through government commitments, deregulation and a favorable insurance climate.6/

The primary advantage of vanpools is the added convenience of relaxing while being "chauffeured" to and from work at a cost much less than the cost of a private auto. This generally ranges from one-third to one-fifth of the cost of owning and operating a private automobile. A survey of vanpool users, half former carpoolers and half former drivers travelling alone, found that 82% considered vanpooling more convenient than their previous mode.7/ As a transportation means, vanpooling comes very close to the commuter's dream of personalized door-to-door transit at low cost. Thus, the idea and practicality of vanpooling has sold itself and now vanpooling is recognized as a commuter mode of transportation.

Certain provisions of the Federal Highway Aid Act of 1976 could further the spreading of vanpooling throughout the nation. This legislation provides funds which may be granted states to encourage development of ride-sharing programs. According to the law, such projects may include:

1. Systems for locating potential riders and informing them of convenient pooling opportunities.

2. Designation of existing highway lanes as preferential lanes for pools and provisions for related traffic control devices.

3. Designation of existing publicly owned facilities as preferential parking for pools.

The funding behind this legislation was established at a maximum level of $7.5 million with no one grant to exceed $1 million. According to current data from the Federal Highway Administration, such grants have enabled more than a dozen large cities to offer some form of special freeway lanes for buses, carpools and vanpools. All but four states now contain one or more ride-sharing agencies.

The Department of Energy is currently providing grant funds to states to implement energy conservation plans under the provisions of Title III of the Energy Policy and Conservation Act of 1975. In order to be eligible for these funds, each plan must include five specific program activities, some of which relate to transportation. The promotion of mass transit and ridesharing is one of the areas specified as a required energy conservation measure.

Under the Clean Air Act, as amended August 1977, State and local governments are revising their State Implementation Plans to include all reasonably available control measures needed to attain air quality standards by 1982, or in some cases, by 1987. Lead local agencies have been designated in each area, and the Environmental Protection Agency, in cooperation with the Department of Transportation, has published transportation-air quality planning guidelines, as well as information documents; and is also providing planning funds to these lead agencies to support the analysis, adoption and implementation of transportation measures, including ridesharing. All areas with serious air quality problems are required to consider vanpooling programs for inclusion in a package of comprehensive measures needed to attain air quality standards.

Fuel Conservation Potential

A report published by the Congressional Budget Office in December, 1977 entitled "Urban Transportation and Energy: The Potential Savings of Different Modes" concludes, "Of all the urban transportational modes, vanpools can probably make the greatest contribution to energy savings on a per passenger-mile basis". A summary of the results of that report are presented in the following table:

Energy Savings by Travel Mode

Mode of Travel	Net Savings (Btu per passenger-mile)
Average Automobile	Base Case
Van Pool	7,720
Car Pool	4,890
Express Bus	3,590*
Commuter Rail	970
Light Rail	30
Heavy Rail (new)	-980
Dial-A-Ride	-12,350

*Conventional Bus Service would show smaller savings.

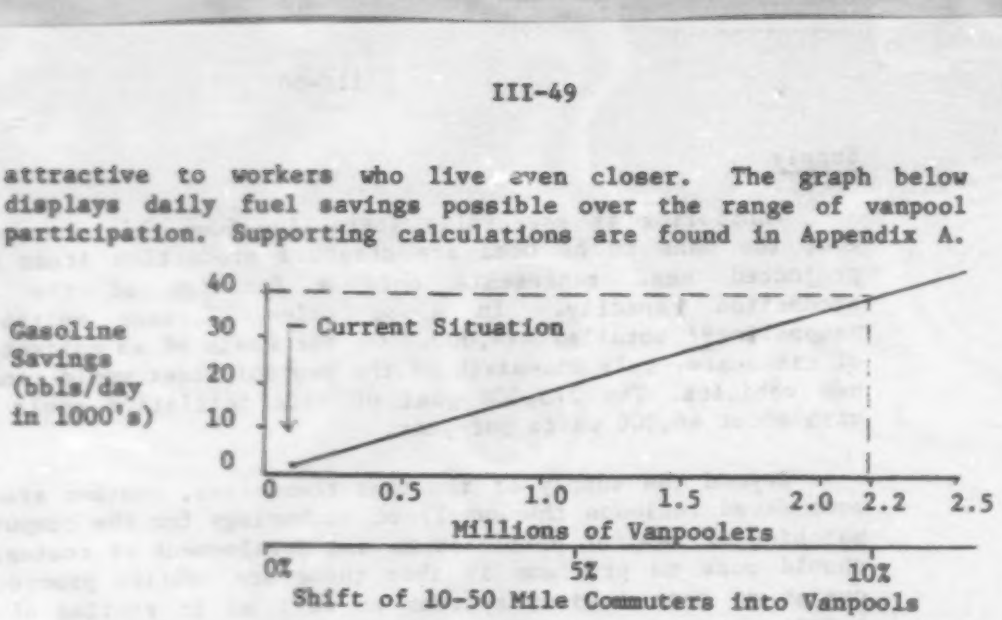
The possible savings shown in the table above can be demonstrated by an examination of the actual savings reported by current vanpool programs. The following table summarizes the experience of several large-scale programs:

Summary of Fuel Savings through Vanpooling8/

Program	Vans in Operation	Annual Fuel Savings (gal. per year)
Conoco	66	8160
TVA	78	7128
3M	92	7391
Commuter Comp.	65	7692

Although these savings may be greater than what can be expected from an expanded range of vanpooling activities, it is clear that vanpools are saving fuel at the present time. In a study conducted for the Department of Energy (DOE) by Stanford Research Institute (SRI) in April of 1978, SRI used current experience to project annual fuel savings in 1985 for several levels of vanpool growth.

A "high growth" value was set at a 5% shift to vanpooling from passenger cars whose owners live 15 or more miles from work. They considered this figure an achievable goal under the economic situation prevailing at that time. One of their major assumptions was that automobile operating costs would double by 1985. Since recent conditions have caused a much steeper rise in such expenses, the objective of a 5% shift has become more reasonable and could be achieved sooner. The 10% shift suggested in this initiative refers to passengers, not cars, and presumes aggressive promotional activities at all levels of government as well as a lower limit of 10 miles for participation. Especially favorable conditions of geographical clustering could make vanpooling attractive to workers who live even closer. The graph below displays daily fuel savings possible over the range of vanpool participation. Supporting calculations are found in Appendix A.



The above graph includes only savings. Other quantifiable factors such as reductions in pollution, commuting costs and chance of accidents have not been addressed.

Cost To Implement

Because of the unique relationship between Americans and their automobiles, candidates for vanpooling must recognize the benefits of this mode of transportation before it can be truly successful. At this time, substantial cost savings while retaining door-to-door service appear to be the greatest incentives. Other advantages such as freedom from driving, safer travelling and social aspects can also be mentioned.

The primary expenses incurred by the Federal Government to achieve a shift to vanpooling by 10% of the commuters who travel 10 or more miles to work will be for public awareness, overcoming resistance from employers, support to state and local governments, and other Federal incentives. (More details of the possible Federal incentive costs are provided in the Implementation Options section). The Federal administrative cost would result from the assembly and maintenance of a small staff. This staff would assemble the appropriate information, design and distribute brochures, arrange for media advertising and interface with state, local and corporate activities. A staff of 16-20 should be sufficient with an annual budget of $2,000,000 to cover salaries, travel, printing and distribution. Media advertising could be presented in the public interest at little cost.

Assuming that a vanpool member will save approximately $930 per year in commuter costs, and that the objective of 2,200,000 members can be achieved, the total annual savings to the public will be over $2 billion and 12 billion vehicle miles-travelled. The commuter cost is based on car operating costs of $.20 per mile over 10,000 miles per year less $500 paid per member in vanpool fares. However, to the extent that vanpools substitute for carpools, the energy savings and per worker savings would be less.

Supply

Vanpooling is especially attractive from this standpoint in that the vans to be used are standard production items and the projected need represents only a fraction of the current production capacity. In 1978, sales of vans suitable for vanpooling[9] totalled 414,000. On the basis of an estimated life of six years, only one-sixth of the vanpool fleet would consist of new vehicles. The 275,000 goal of this initiative could be met with about 46,000 units per year.

Beyond the supply of the vans themselves, another area to be considered includes the supply of technology for the computerized matching of vanpool participants and development of routes. This should pose no problems in that these are routine procedures in design of mass transit systems as well as in routing of school buses.

The final aspect of supply is the staffing and legislation required at the Federal level. With only a minor reorganization, there are enough Federal employees already working in this area to provide the initial staffing. In terms of legislation, the Federal Highway Aid Act of 1976 set aside $7,500,000 in grant funds to promote ride-sharing programs. The existence of this Act indicates that Congress would be receptive to legislation encouraging vanpooling. Further legislation could provide for budget allocations and restructuring of tax laws to rapidly promote vanpooling.

Impacts

The greatest impacts of vanpooling will be positive and will be primarily in the area of fuel consumption and commuter costs. Other favorable impacts include reduced traffic congestion and less pollution in the more densely populated areas where vanpools will be concentrated.

There are several negative areas which should also be addressed. One of these is possibly increased commuting time and scheduling problems. In order to be attractive to prospective participants, vanpooling should not require much extra time. Some additional travel time could be justified on the basis that it is no more than the commuter would have spent refueling or maintaining his private vehicle. Vanpools could be awarded special highway lanes or preferential parking with other multiple occupant vehicles but these cases would have to be treated individually by local authorities or sponsoring companies. Vanpool operators should also seek means to ensure that each passenger, as well as the van itself, is ready on schedule. This aspect will have a great impact on participant satisfaction. Employers must be willing to accept these schedule requirements, forego some casual overtime and allow flexitime hours to mesh schedules better. Workers must be prepared to take work with them to accomplish at home (or in the van).

The economic impact of a reduction in the number of automobiles should also be considered. Although the modest shift to vanpooling should not greatly upset the equilibrium, every sector of the economy which is related to the auto industry will tend to be affected. This includes auto companies, their suppliers, aftermarket parts firms, the service industry, roadbuilding contractors, the insurance companies and all levels of government which obtain funds through vehicle ownership and use. This includes sales and use taxes on vehicles and fuels in addition to revenues from tolls and speeding tickets. The ultimate cost of these redirections should be greatly offset by the benefits of vanpooling, although tax breaks and other subsidies could be employed during any transition period.

Another consideration is "urban sprawl". This phenomenon has occurred because of the commuting range of the automobile. While rising operating costs have made long commutes a greater burden, vanpooling could relieve this burden. This is a long-term consideration, however, and should have only a minimum impact of the situation at hand.

A final concern in transportation mode shifting is the impact of a gain in one mode on the ridership in another. Urban mass transit should not be affected by vanpooling because each serves a different population in terms of distance to work. Almost 95% of current vanpools serve suburban or rural employment locations at an average of 50 miles per day round trip. The average transit commuter makes only a 12 mile round trip.10/ Vanpooling could have an impact on carpooling since it appeals to the same set of commuters. If this vanpooling initiative is successful, the carpool mode should benefit from the computer matching of potential participants. Other forms of travel to-and-from work do not represent a significant portion of the current or projected situation.

Implementation Options

Since the implementation of this initiative will affect such a wide range of interest in such a short time, a number of means could be used in concert. The actual intensity of each and the ultimate mix can be adjusted as the program progresses. Initially, however, vanpooling should be promoted at the level of the potential participant. Consumer information could include pamphlets, media advertising, press releases on successful programs and demonstration efforts. An initiative that involves large scale shifting of transportation modes can only be truly successful through the interest and willingness of the participants.

The Federal Government can foster participation in vanpooling through appropriate economic incentives which reduce the burdens on owners and operators, and overcome the disinterest or resistance from employers. This can be done through various tax breaks, subsidies and guarantees of fuel supplies. The complete success of this initiative depends on vanpools which include members from different, yet geographically clustered, places of employment. Here the Federal Government could provide technical and monetary assistance to States and localities in establishing or sponsoring vanpool "brokers". Such brokers would use computers to group commuters and establish routes. This information could also be used to encourage carpools where vanpooling is not feasible. Based on the situation, other incentives could include preferential parking or special roadways. Economic disincentives such as higher taxes or parking surcharges are also possible.

Support to state and local governments could include direct encouragement for their own vanpooling as well as assistance to them in helping private organizations under their jurisdiction. Encouragement for their own vanpools could be in a form similar to that used with corporate programs. Federal support to help them initiate and foster vanpooling in the private sector could consist of technical assistance, materials for public awareness and partial compensation for expenses. Local governments or transportation authorities could work together to recognize and delineate clusters of commercial and residential areas which would be appropriate for the concept of vanpooling. They could also act as a clearinghouse to gather names and addresses of potential participants from companies as well as individuals. This information could be computerized locally or through Federal efforts to develop the details of the most efficient vanpool operation. Partial reimbursement to State and local governments to conduct operations related to vanpooling could cost approximately $1 million per state for a total of $50 million.

In addition to the technical support and compensation the state and local governments will receive, they could also be rewarded in some other manner. Local governments could receive more favorable treatment in distribution of Federal funds based on their success in vanpool implementation. State governments, faced with the loss of gasoline tax revenues, could be reimbursed or could raise taxes to offset the loss. At the 10% level of vanpooling these lost revenues could easily amount to approximately $40 million per year.

As the potential participants are convinced of the worth of vanpooling, their employers could also be encouraged to participate. The most successful vanpools have been sponsored by organizations who can take advantage of fleet discounts in purchase and operation of vans and in group insurance policies. Generally, the employers have not had much to gain from vanpooling.

For the 10% level of vanpooling to be realized, the corporate sector may have to take an active role. Beyond the small but obvious benefits such as reduced plant congestion, mobile advertising, and more efficient use of company land, there must be some real and substantial economic incentives. These could easily take the form of tax breaks. Various levels of compensation could be offered to companies for purchases of vans to be used in vanpool service. A reasonable approach may be an investment tax credit for van purchases. Legislation passed by the 95th Congress provides for investment credit for certain commuter vehicles. With the enactment of the Energy Tax Act of 1978, employers who provide a van or bus to transport their employees to and from work will be eligible for the full 10 percent investment tax credit in 3 years. The van or bus must have at least a 3-year useful life; be acquired after the date of enactment; and be placed in service by the employer before January 1, 1986. The commuter highway vehicle must have a seating capacity of at least eight adults, not including the driver; at least one half of the adult seating capacity must be occupied, not including the driver; and at least 80 percent of the mileage must be used for commuting.

If an alternative credit were set at 10% of the purchase price for a 6 year minimum use period, this would cost approximately $33 million per year in foregone tax revenues. Other incentives could consist of rebate on fuel costs for purchase of efficient vehicles, other economic favors, or government awards with appropriate publicity. The figure for foregone revenues is based on the assumption that 75% of the vans (approximately 200,000) will be purchased by corporations and that each will cost $10,000 and last for six years. This will mean new vehicle purchases of 33,000 units per year. Ten percent of the total purchase price is $33 million.

Direct assistance to vanpoolers from the Federal Government could take several forms. Since the participants themselves are enjoying a less expensive mode of transportation, little additional incentives need to be offered. Reinforcement here could be in the form of a small tax credit, perhaps related to income level versus annual fares. Incentives to the driver of the van could vary depending on whether or not he was the owner. Operators of vans owned, fueled and insured by a third party could receive only a small reward; perhaps tax-exempt status on any income derived from acting as its driver. Support to operators who also owned the vehicle and provided for its insurance and fuel could be much greater. Tax credits could be employed or the operator could be allowed to depreciate the vehicle as long as he could prove it to be in vanpool service. Monetary incentives could also increase proportionately with the size of the pool to further reward the driver. State and local regulations, e.g. Chauffeur's license or business operating permits, could be made more favorable for an individual wishing to establish a single vanpool. Tax incentives in this case could include breaks in insurance costs above what he pays as a car driver, as well as tax exemption on any earned income. He could also be granted some guarantee of immediate fuel availability in case of shortages and long lines. Given the encouragement to corporate ownership of vans, perhaps only 25% would be owned by individuals. Thus, approximately $13 million per year in tax revenues would be foregone. This calculation is based on the same assumptions as those used for the corporations. In order to encourage vanpools to continue past the first year, consideration could be given to lengthening the term of the tax credit just as depreciation would only be allowed while the vehicle was in vanpool service.

An alternative approach would be an annual tax credit/rebate based primarily on the number of passengers carried. Such an approach has an advantage over the tax credit for the purchase of the van since it encourages the van owner to generate ridership, to operate his van economically and to purchase the most cost-efficient van. (It rewards performance - the saving of fuel). Specifically, the owner of a van who operated it in vanpool service could receive a tax credit/rebate on the basis of the following table.

	Tax Credit/Rebate	
Average Passengers* (excluding self)	3-10 Miles One-Way	More than 10 miles One-way
1	25	100
2	50	200
3	75	300
4	100	400
5	125	500
6	150	600
7	175	700
8	200	800

* Must have signed statement on record of ridership to average as indicated over the calendar year.

A tax credit on the purchase of a van, being a one time benefit, is complicated to enforce against abuses - to assure continued use for vanpooling over the prescribed period. Also, there would be less incentive for the owner to increase the ridership in his vanpool. In addition, fuel cost and/or parking subsidies are, in comparison to the performance-based incentive, complex to administer and do not necessarily encourage the purchase of the most fuel efficient vehicle.

The economic incentive reflected in the table above, assuming that the incentive was sufficient to convert 10% of the commuters who live over 10 miles from work to vanpooling, would save about

41,000 barrels of fuel per day. The "cost" to the Federal government for this incentive would be about 220 million dollars per year or about 35¢ per gallon of fuel saved.

One criticism of the "performance incentive" might be that it does not provide increased credit for longer one-way trips, i.e., it does not distinguish between vanpools which operate 11 miles one way from vanpools which operate 50 miles one way. This is by design. Commuters who live long distances from work already have the greatest economic savings (due to fuel savings) to vanpool, and most importantly, the incentive should not encourage long commute trips, as it would if the incentive increased with the commute distance.

Recommendations

From the facts presented above, it is clear that vanpooling promises a significant reduction in nationwide fuel consumption in addition to a substantial individual savings for commuters who participate. The following recommendations encompass a plan to foster the growth of vanpooling to achieve the stated objective, i.e., 10% of all commuters who live over 10 miles from work converted by the end of 1985:

1. Announce that Vanpooling is a Nationwide Objective. The President should proclaim that ride-sharing programs are a vital part of our energy conservation efforts. He could synopsize the basic energy, economic and environmental benefits in terms the public can understand. This should be done as soon as possible. Such an announcement by the President would reach the greatest audience in the shortest period of time. It should be attractive from a political standpoint in that it can be implemented with only positive incentives.

2. Establish a Staff at the Federal Level. Since the success of this initiative will depend on an integrated approach at all levels of government, a central organization is required to coordinate the activities of the States and localities. This group would oversee research and development in this area, obtain and administer grant and contract funds, provide technical support to legislative actions, and evaluate the progress and results of the overall effort. This staff should be aided by a commission of cognizant authorities at all levels of vanpooling. (This is not intended to imply a recommendation to expand Federal involvement, but rather a consolidation of existing Federal efforts.)

3. Encourage State and Local Leadership of Ride-sharing Programs. In the case where prevailing market conditions bear so greatly on the ultimate success of this initiative, involvement of the local authorities is a prerequisite. The first aggressive task of the Federal staff will be to develop

means to foster interest at the local level. This can come through various forms of funding in addition to technical and administrative support.

4. Create a Public Environment Conducive to Vanpooling. Although vanpooling is a concept which can sell itself, the full potential of this initiative cannot be realized unless certain obstacles are overcome. This should be the second major effort of the Federal staff. Among these obstacles are corporate disinterest and insurance problems.

5. Implement Vanpooling at Government (Especially Federal) Installations. The national commitment to ride-sharing should be demonstrated to the general public. Current regulations governing the use of public vehicles should be examined for ways to properly operate vanpools. Otherwise, third parties, such as financial institutions or commercial vanpool operators could be encouraged or contracted with to assist government employees in the purchase and operation of vans. These programs could supply valuable first-hand information on the technical and cost aspects of vanpool programs. The Federal staff should undertake this as its third major activity.

6. Establish a Strong Economic Incentive. A Federal tax credit/rebate based primarily on the number of passengers carried should be established. The annual credit would provide $100 per passenger for vanpools of more than 10 miles one-way distance. This would provide strong stimulus for vanpooling.

Appendix A

Calculation of Savings through Vanpooling

Assumptions:

1. By 1985, 85,000,000 people will be in the non-agricultural work force.
2. 76% of these, i.e., 64,600,000, will be located in urban or metropolitan areas.
3. 34% of this number will live 10-49 miles from their place of employment. Average round trip commuting distance for this group is estimated to be 40 miles using a weighted combination of the linear interpolations for the 10-19 and 20-49 mile groups.
4. Each vanpool will average 8 members.
5. Since average commuter cars contain 1.4 persons, each van will replace 5.7 cars.
6. Average fuel economy for these cars is 18 mpg.
7. One barrel is equal to 42 gallons.
8. There are 250 working days in a year.
9. A typical van will travel 50 miles per day at 14 miles per gallon. No extensive dieselization of the vanpool fleet is projected within this time frame.

Thus, the target population for vanpooling consists of 22,000,000 commuters.

Each of these cars would have travelled 40 miles per day at 18 miles/gallon. Ten percent of these vehicles would consume 3.5 million gallons per work day for an annual usage of 875 million gallons. This equates to 57,000 barrels per day or 21 million barrels per year.

On the other hand, the 275,000 vans which replace them will travel 50 miles per day at 14 miles per gallon. Thus, they will consume 0.98 million gallons per day or 245 million gallons annually. In terms of barrels, the daily and annual rates are 16,000 and 5.8 million, respectively.

On the basis of the estimates above, the fuel savings to be expected through this initiative are 2.5 million gallons per work day, or 41,000 barrels per calendar day.

References

1/ "Evaluation of the FEA Vanpool Marketing and Implementation Demonstration Program", Publication Number HCP/J60438-01 dated April 1978, prepared for DOE by SRI International.

2/ "MVMA Motor Vehicle Facts and Figures-1979", Motor Vehicle Manufacturers Association.

3/ "Marketing Plan to Accelerate the Use of Vanpools" Publication Number HCP/M60437-01 dated December 1977, prepared for DOE by Grey Advertising, Inc.

4/ "Carpool Incentive and Opportunities", U.S.DOT, February 1975.

5/ "Statistical Abstract of the United States 1978" U.S. Department of Commerce, Bureau of the Census.

6/ "Vanpools can find wide open highways" Detroit Free Press, February 18, 1980.

7/ Op. Cit. Reference 1.

8/ Ibid.

9/ Op. Cit. Reference 2.

10/ "Vanpooling...An Update", Publication No. DOE/CS-0031 UC-96, dated May 1978, Robert Gray (EPA), Lew Pratsch and Ruby Starling (DOE).

Energy Savings Through the Increased Use of Video-Telephone Conferences

Summary

The video-telephone offers a cost-effective alternative to intercity business travel that is available now in 12 major U.S. cities and will soon be available nationwide.

It is estimated that from 20 to 36 percent of business-related air travel could be replaced by video-conferences.5/ This would translate into a fuel savings of 49,000 to 88,000 barrels of jet fuel per day.

Efforts to hasten the realization of this potential hinge on acceptance by the corporate community. This study, therefore, makes the following recommendations:

1. Increased government utilization of teleconference facilities;
2. Increased usage by government contractors;
3. Government/industry-sponsored demonstrations;
4. Federal financial assistance (25 percent tax credit) for a period of 1 year to new users of the system;
5. FCC standards to facilitate system-to-system compatibility.

If this initiative is successful in shifting 20% of the business-related air travel to video-conferences, then about 49,000 barrels of fuel per day can be saved at a "cost" to the Federal government through the new-user tax credit of about 150 million dollars per year or about 20 cents per gallon of fuel saved.

Background

The growth experienced by the airline industry since its conception only a few decades ago has been monumental. In 1960, approximately 34 billion passenger-miles were accrued by air travel.1/ By 1977 the number of passenger-miles had increased to over 174 billion via the air mode, an increase of roughly 500 percent.1/ Clearly the once-fledgling airline industry now rests on a firm foundation.

Burgeoning airline patronage has also had portentous ramifications on the nation's energy budget. Jet fuel consumption in 1977 by air carriers totaled over 257 million barrels; by comparison, intercity buses consumed roughly 4 million barrels that same year and passenger railroads approximately 3 million barrels of fuel.1/ Recent efforts by the airline industry to reduce fuel consumption have been instigated. Measures such as reduced cruising speeds, single engine taxing after landing, and computerized flight plans are largely responsible for the 19 million barrel decline in airline fuel consumption between the 1973 and 1976 yearly totals.2/ Still, the airplane remains the most fuel intensive mode of intercity passenger transportation; it is nearly 6 times as energy intensive as the bus.1/ Any initiative which would induce a shift from air to more efficient modes would clearly have a positive impact on reducing the country's reliance on foreign oil.

Many trips by airplane are of course unavoidable; business trips, for example, are largely out of necessity. The inherently low travel time, resulting from high cruising speeds, make the airplane an especially attractive mode for this trip purpose (constituting 34.4 percent of air person-miles in 1976).1/ Of the three conventional alternatives to the air mode of intercity passenger transport (bus, rail, and car), the high-speed train offers the most viable competition in the long-range, greater than 500 miles, market. Such trains, however, are available only in limited corridors and are very costly to develop. The Northeast Corridor Project, for example, will connect Washington, D. C. and Boston with a high-speed rail system for a cost of approximately $2.5 billion;3/ targeted travel times are 2 hours 40 minutes from Washington to New York City and 3 hours 40 minutes from New York to Boston.

A more rational alternative to intercity business-related air travel can be found by considering the primary purpose for such trips: the exchange of information. Many business trips which have this purpose could be avoided through the expanded use of interactive audiovisual communications.4/5/9/10/

Fuel Conservation Potential

A. Substitutability

The best study available which addresses the question of how many intercity business trips can be substituted for by telecommunications was performed by the Business Planning Group of Bell Canada.9/ This work focused on the intercity business travel along four Canadian corridors. By using a questionnaire, it was found that: "Approximately 20 percent of the business travelers sampled would not have taken their current trip had an acceptable communications alternative been available." Two caveats should be considered, however, when interpreting their finding as it relates to this study: 1) their research dealt with business travel by auto and train as well as airplane; and 2) it only examined travelers with trip lengths of less than about 350 miles. Thus while the first point would tend to decrease the percentage of air flight substitution from the 20 percent level, the second would, in the case of travel in the United States, increase the degree of air substitution since many trips are of a greater distance than the 350-mile scenario of the Canadian research.

Another study which examined the substitutability of business trips by telecommunications was performed by the United States Department of Commerce.10/ Here, data on business meetings and travel costs were collected from six OECD* countries and assimilated into a teleconferencing demand model. Preliminary results for the United Kingdom indicate that roughly 36 percent of the business trips there could be replaced by teleconferences (based on projected 1985 costs).

Other less detailed estimates of the substitutability of business trips by teleconferencing range from Booz, Allen and Hamilton, Inc.'s 50 percent,4/ to the "rather large potential" cited in reference 7.

Thus it is clear, as expected, that an absolute determination of the business travel substitution potential of teleconferencing is unavailable. This study will therefore examine the ramifications of the 20 to 36 percent range since these estimates involved the most in-depth analyses.

B. Fuel/Energy Conservation

A number of studies have been undertaken to determine the fuel savings potential of substituting airplane trips with interactive autiovisual communications. Dickson has made an energy comparison of video-telephones and airplanes on a per trip basis.7/ Using fuel consumption data for a Boeing 747 operated by American Airlines, Inc. and a hypothetical trip from New York City to Los Angeles, the round trip fuel consumption per passenger was determined to be 241 gallons. Given 39.5 kilowatt-hours per gallon of fuel, the energy requirement per passenger on a round trip basis was estimated at 9520 kilowatt-hours.

By contrast, Dickson has determined, using A T & T data,8/ the net power requirement of a two-city Picturephone conference to be 149 kilowatt-hours per hour. For an 8-hour conference, total energy consumption would thus be roughly 1,200 kilowatt-hours, a factor of 8 less than that calculated for the air trip outlined above.

The National Transportation Policy Study Commission (NTPSC) estimates that a 20 percent reduction in business travel by air would save approximately 50,000 barrels of petroleum per day, 17.5 million barrels per year (based on 1974 data).5/

Using the Department of Energy's Transportation Energy Conservation Data Book,1/ it can be calculated that in 1977, 88.4 million barrels of jet fuel were consumed due to business trips. A 20 percent reduction of this total would be approximately 17.7 million barrels, in agreement with the NTPSC's estimate. A 36 percent reduction would yield a savings of 31.8 million barrels per year, 87,100 barrels per day.

---

* Organization for Economic Cooperation and Development

It is important to realize, when estimating the fuel savings through business trip substitution, that one canceled airplane trip does not necessarily translate into a fuel savings if there is no accompanying reduction in airplane flights. This implies that at low levels of substitution there will be little if any fuel savings. Ultimately, however, as the degree of substitution increases flights will be curtailed; under this scenario the projected 20-36 percent fuel savings should be valid.

Cost to Implement

A. Cost Comparison of A T & T's PMS and Air Travel

A T & T's Picturephone Meeting Service (Trademark) is available now in 12 U.S. cities (refer to the discussion on Supply) at a cost competitive with the airlines. Typical costs for a 2-hour teleconference are given below, along with round trip air fares for two people.

City Pairs 5/6/

	New York/ San Francisco	Chicago/ Washington D.C.	New York/ Washington D.C.
Teleconference	$ 780	$420	$300
Airfare	$1288	$440	$240

The cost comparisons between the two modes, as depicted above, do not account for lodging and meal expenditures which would be incurred concomitantly with the airplane fare. Thus, teleconferencing is even more cost competitive with air than is indicated above.

B. Cost to the Federal Government

Any cost to the government of implementing the proposed options reside primarily in the extent of Federal reimbursement (tax credit) to users of teleconferencing facilities during the yearlong trial period. In 1977, approximately $100 million was spent on various forms of teleconferencing in the United States.5/ If 25 percent of this amount were credited towards corporate tax breaks, then the cost to the Federal government would be $25 million. Portions of the windfall profits tax could be reallocated for this purpose. If the goal of 20 to 36 percent of the business air travel is substituted with teleconferencing, then the "cost" to the Federal government would be from about 150 to 270 million dollars per year or about 20 cents per gallon of fuel saved. These costs were calculated using the following assumptions:

1. 30 million business trips per year.1/

2. Average business trip approximated by Chicago/Washington D.C.

3. 2-hour teleconference is sufficient on the average.

4. Teleconference cost of $420/"trip-equivalent".

5. That on the average a new user will continue to use the system for 3 more years.

Supply

Video-conferencing centers are available today; the most noteworthy being American Telephone and Telegraph Company's (A T & T) Picturephone Meeting Service (PMS) (Trademark), although a few large companies have their own conferencing centers. The A T & T system connects conference centers in Chicago, Los Angeles, Atlanta, Detroit, San Francisco, Pittsburgh, Washington, D. C., Philadelphia, New York City, Boston, Dallas, and Sacramento;11/ it is interesting to note that airports at these cities are responsible for over 40 percent of U. S. enplanements.1/

Each conference center, in the A T & T system, has two television monitors, enabling each participant to watch either half of the meeting. The reception is television-type video, showing people in full motion. While full-motion color is being tested in Los Angeles and New York, resolution is still not good enough for graphs and documents.5/ Documents can be transmitted, however, either over a 4-minute facsimile device, or through the use of a prefocused camera. The latter approach will transmit a copy of the document in 10 seconds.

The existing A T & T system is in the trial marketing stage, under FCC tariff 263 until June 1981. At that time a decision will be made as to the future of PMS (Trademark).13/ One marketing approach being considered is to offer a similar system to individual businesses to be installed in their own facilities. Cost estimates of such a system are unavailable at this time due to tariff restrictions.

Since A T & T's Picturephone Meeting Service (Trademark) is the most advanced teleconferencing system currently available, the energy conservation potential of substituting business trips with video-conferences is a strong function of the degree of their systems' deployment. It is believed that their decision will be an affirmative one for a number of reasons. First, teleconferencing is an electronically intensive mode of communications. The ongoing revolution in the electronics industry lends itself to developments such as the one outlined above as cheaper and better technology burgeons. Second, the need for expanded teleconferencing capabilities is not only based on an energy conservation potential but also on monetary and time savings, important factors to the business community. Third, a number of other companies are committed to the development of similar systems.

One such competitive video-conference network will incorporate a dual satellite system and will become available in January 1981.12/ It is being developed by Satellite Business Systems (SBS), a partnership sponsored by Aetna Life and Casualty, COMSAT General Corporation and IBM. Unlike the current A T & T system, SBS customers will have the conference facilities (and hence the parabolic antenna system as well) installed permanently on their own premises. Preliminary installation cost estimates range from $150,000-500,000 with an additional 5 percent per year operating and maintenance cost.14/ These costs should, however, be substantially lowered as the laws of "economy of scale" begin to apply.

The SBS system has the following additional characteristics:

1. Each SBS satellite will be able to carry information that is the equivalent of more than 12,000 telephone lines.
2. Expected satellite lifetime is 7 years.
3. Teleconferencing could be either full motion or freeze-frame.
4. The transmission of "hard copy" letters will be speeded by a factor of 2 to 20 times over current facsimile transmission.

Given that teleconferencing facilities are not only available now (with more scheduled to begin operations in January 1981), but are also cost competitive with airline travel, no major impediments are foreseen which would deter the expanded use of teleconferencing. The need for additional transmission lines and relay stations will arise, given substantial expansion. This need, however, should be well within the capabilities of such industrial giants as A T & T.

Impacts

It is conceivable that as the use of interactive audio-visual equipment expands, a demand for similiar facilities in the home will be spawned. This usage could replace many auto trips to visit friends and relatives, thus saving more fuel. These projections, however, are of a long-term nature.

On a near-term basis, the airline industry appears to be the most adversely affected segment of society given a scenario of increased teleconference substitution. The National Transportation Policy Study Commission estimates that a 20 percent substitution for business air travel would result in a $1 billion reduction in passenger revenues at 1975 levels.5/

In addition to the positive economic effects on the telecommunications industry, beneficial environmental and safety ramifications will also result as congestion over many of the nation's airports is lessened. Reductions in air pollution, noise, and fatalities should be directly proportional to reductions in the number of flights.

Implementation Options/Recommendations

Given the monetary, energy, and time savings that can be realized through the use of teleconference facilities, as opposed to air flights to business conferences, it is not readily apparent why the video mode is not utilized even more. Certainly, the inconvenience of driving to a centrally located video-conference center is a contributing factor. This situation, however, should be alleviated as more systems become available for installation on a business' own premises. The National Transportation Policy Study Commission proposes that "the greatest deterrent in institutional use of telecommunications is inertia--the tendency of a system, such as a corporation, to continue on its present course."5/

It follows, therefore, that the potential benefits of teleconferencing are not readily known in the business community. The following steps should be taken to alleviate this situation:

1. A certain percentage of each Federal agency's travel allotment should be devoted to teleconferencing where available; the degree of reallocation to be determined jointly by GSA and the affected agency;
2. Consultant firms engaged in business with the U. S. government should be encouraged to use teleconferences in their dealings with the contracting agency;
3. A teleconferencing "open-house" should be held in every major U. S. city to demonstrate the capabilities of the system.
4. The "open-house" should be followed by a partial Federal monetary reimbursement to new users for a period of 1 year. This reimbursement would take the form of a 25 percent corporate tax credit.
5. The Federal Communications Commission should actively investigate the feasibility of standards of performance with the goal of interconnectability among the various video-telephone networks expected to develop in the coming years. A similar system already exists in the telephone industry.

References

1/ Transportation Energy Conservation Data Book, 3rd Edition, Oak Ridge National Laboratory, February 1979.

2/ Proceedings of the Fourth National Conference on the Effects of Energy Constraints on Transportation Systems, U. S. DOE, Contract NO.EC-77-G-01-60-67, December 1977.

3/ Personal Communications with Robert Hippart, Federal Railroad Administration, February 12, 1980.

4/ Aetna Tries Using TV to Cut Travel Cost, Business Week, March 6, 1978, pp. 34-35.

5/ The Impact of Telecommunications on Transportation Demand Through the Year 2000, National Transportation Policy Study Commission, Special Report No. 3, November 1978.

6/ Official Airline Guide, North American Edition, March 1, 1980.

7/ Edward M. Dickson and Raymond Bowers, The Video Telephone, Impact of a New Era in Telecommunications, Cornell University 1973.

8/ "The Picturephone System," A Special Issue of Bell System Technical Journal, February 1971, pp. 219-700.

9/ J. Kollen and J. Garwood, "Travel/Communications Tradeoffs: The Potential for Substitution Among Business Travelers," Business Planning, Bell Canada, Montreal, Canada, 1975.

10/ M. Tyler, et al., "The Contribution of Telecommunications to the Conservation of Energy Resources," Office of Telecommunications, Department of Commerce, Washington, D.C. July 1977.

11/ Personal Communications with Dianne Ryding, Michigan Bell Telephone Company, Detroit, Michigan, February 1980.

12/ The SBS Digital Communications Satellite System, Satellite Business Systems, McLean Virginia.

13/ Personal Communications with Bob Schanks, A T & T, Washington, D.C. March 1980.

14/ Personal Communications with Rich Harkness, Satellite Business Systems, McLean Virginia, March 1980.

Time and Cost Incentives for Modal Shifts to Intercity Bus

Summary

An initiative is proposed whereby an incentive approach, rather than one relying on disincentives, is developed to promote a mode shift from the more inefficient modes of passenger transportation to the energy-wise bus mode.

A 70 mph speed limit for intercity buses operating on Interstate Highways and a Federal tax credit/rebate of 0.3 cents per passenger-mile are recommended. The 70 mph speed limit will reduce highway travel time up to 27% and should result in passenger shifting primarily from automobiles to buses, with perhaps even a reduction in fatal accidents in spite of the increased speed limit. The tax credit/rebate is designed to reward performance and should stimulate the bus industry to work harder to attract new customers - to be more courteous to riders, to renovate terminals, to modernize and make more fuel efficient the bus fleet, and to foster fare reductions.

If these incentives are successful to shifting 10% of the intercity automobile passenger-miles to buses, then about 180,000 barrels per day of fuel can be saved at a "cost" to the Federal government through the tax credit/rebate of about 450 million dollars per year or about 16 cents per gallon of fuel saved.

Background

A. How Energy is Used in Intercity Travel

Intercity passenger-miles traveled totaled approximately 1453 billion in 1977, an increase of over 85% from the 1960 level (see Table 1). 1/ Significantly, the automobile share of intercity passenger-miles declined in that period from 90 to 85%, even though the total number of auto passenger-miles increased by over 532 billion. The emergence of the Interstate System has played a vital role in this growth, with more than 39,412 miles of the total 42,500-mile system open to traffic in 1978. 2/ The Interstate System, together with its principal arterials, accounts for only 2.5% of rural highway miles yet carries over 40% of the travel in rural areas. 3/

Fuel consumption by automobiles in intercity use in 1977 was approximately 833 million barrels of gasoline. This value was derived from the following data:

1. 1238×10^9 intercity passenger-miles, p. 1-17. 1/

2. 2.4 passengers per intercity automobile, p. 27. 6/

Table 1
Intercity Passenger-Miles by Mode of Travel, 1960-1977 (percent)

	Automobiles[a]	Buses[a]	Total motor vehicles[a]	Railways, revenue passenger	Inland waterways	Airways, domestic revenue service	Total (%)	Total passenger-miles (10^9)
1960	90.03	2.54	92.57	2.75	0.34	4.34	100.0	784.3
1970	86.59	2.13	88.73	0.91	0.33	10.01	100.0	1134.8
1971	87.12	2.07	89.19	0.72	0.33	9.75	100.0	1229.4
1972	86.82	1.97	88.79	0.67	0.31	10.23	100.0	1300.3
1973	86.40	2.00	88.40	0.70	0.30	10.60	100.0	1348.8
1974	85.00	2.20	87.20	0.80	0.30	11.70	100.0	1259.4
1975	85.80	1.90	87.70	0.80	0.30	11.20	100.0	1310.5
1976	85.40	1.80	87.20	0.70	0.30	11.80	100.0	1390.2
1977	85.20	1.80	87.00	0.70	0.30	12.00	100.0	1453.4
Average annual rate of change (1970–1977)	–0.2	–2.4	–0.3	–3.7	–1.4	2.6		3.0

[a] Includes intra-city portions of intercity trips. Omits rural-to-rural trips, strictly intra-city trips with both origin and destination confined to same city, local bus or transit movement, nonrevenue school, and government bus operations.

Source: *Motor Vehicle Facts & Figures '78*, Motor Vehicle Manufacturer's Association, Detroit, p. 54. (Original source – Interstate Commerce Commission and Transportation Association of America.)

3. 3523 Btu's per route-passenger-mile at 2.4 passengers, p. 2-33. 1/

4. 125,000 Btu's per gallon of gasoline, p. A-5. 1/

5. 42 gallons per barrel.

Buses have also benefited from the nation's Interstate System with approximately 21% of their intercity vehicle miles traveled being via its network.4/ In 1977, 1.8% of intercity passenger-miles were by bus, down from 2.5% in 1960.1/ This represents a decrease of over 6 billion passenger-miles. The National Transportation Policy Study Commission projects a continued decline in the bus industry's modal share but a moderate increase in the total number of passenger-miles through the year 2000.5/ Fuel consumption by buses in 1977 intercity use was roughly 0.5% of that used by automobiles in the intercity market, amounting to 4.3 million barrels.

Railway passenger-miles have fallen substantially since 1960 when 21.6 billion passenger-miles were accrued.1/ Only 10.2 billion passenger-miles were accumulated in 1977, a decrease of over 50%. The decline of railroad passenger travel has been slowed in recent years, however, due to the influx of Federal funds. When Amtrak assumed responsibility for most passenger rail operations in 1970 there were less than 300 daily departures, with yearly losses at $252 million.5/ As of 1977 Amtrak served 532 places with 350 locomotives and approximately 2,000 rail cars.5/ Diesel fuel consumed in the Intercity rail passenger market totaled slightly over 3 million barrels in 1977, placing it just under intercity bus consumption in that year.1/

When observing trends in passenger modes of travel over the past two decades, one mode stands unique with regards to growth: air travel. The airline industry has indeed experienced a bonanza since 1960 when slightly over 4% of that year's total 784 billion passenger-miles were by air (refer to Table 1). By 1977 the modal fraction had increased to 12% of that year's 1,453 billion passenger-miles: an increase of over 500% from the 1960 level.1/ This growth is even more phenomenal when one considers that the fleet size in 1977, approximately 2,200 planes, is not much larger in number than the 1960 fleet.7/ Just over 257 million barrels of jet fuel were consumed by air carriers in 1977.1/ A summary of these and other related data is presented in Table 2.

B. Evaluation

In order to delineate the energy implications of the passenger-miles traveled and fuel consumption data of the previous section, it is necessary to consider the relative thermodynamic efficiencies of each mode. From Table 2 it can be seen that at current load factor and circuitry characteristics, buses are the most efficient mode of intercity transport, cars second, followed closely by rail, with air carriers by far the most energy intensive. It is important to note

Table 2

Pertinent Modal Characteristics

	Bus	Train	Auto	Plane
Energy Intensity* Btu/PM	1092 1/	4518 2/	4270 3/	6580 4/
Load Factor**	41.7 5/	40.6 5/	2.4/car 6/	55.8 5/
Average mpg	6.0 7/	—	13.94 8/	--
Average Fare cents/mile	6.0 9/	5.56 10/	—	8.16 10/
Fuel Consumed 10^6 barrels/year (1977)	4.33 11/	3.12 11/	833. 12/	257.3 11/

1/ Transportation Energy Conservation Data Book, ORNL, February 1979, p. 2-39.
2/ Ibid, p. 2-47.
3/ Ibid, p. 2-33; and Energy Efficiency of Various Transportation Modes; NAS, 1978.
4/ Transportation Energy Conservation Data Book, ORNL, February 1979, p. 2-41.
5/ Ibid, p. 1-20.
6/ Energy Efficiency of Various Transportation Modes, NAS 1978.
7/ America's Most Fuel Efficient Passenger Transportation Service, American Bus Association, 1979.
8/ Highway Statistics, U.S. DOT, Report #FHWA-HP-HS-77, Table VM-1.
9/ Personal Communications with Wes Allen, American Bus Association, February 1979, 1980.
10/ National Transportation Policies Through the Year 2000, NTPSC, June 1979, p. 16.
11/ Transportation Energy Conservation Data Book, ORNL, February 1979, p. 2-15.
12/ Consult text.

* Energy intensities in this table are calculated on a great-circle-mile basis, in order to facilitate intermodal comparisons.

** Load factors are expressed as a percentage of capacity, except for the auto.

that the energy intensity of the rail mode could be substantially improved by increasing its load factor from its existing level, approximately 41%. Though this argument holds for other modes as well, the capacity for increase is greatest in the rail mode.

By considering the relative energy intensities, the pattern of modal selection which has developed over the past two decades can be deemed counter-productive from an energy conservation perspective. The mode showing the greatest growth in passenger-miles traveled, air carriers, is also the most inefficient intercity transportation mode with regards to energy consumption. Over the same time span, the most energy efficient intercity mode, the bus, has experienced declining usage, as has the potentially efficient rail system. Auto usage, less efficient than buses by a factor of four, increased by 75% from 1960 to 1977.

Clearly the potential exists whereby modal shifts to the more efficient modes could result in considerable fuel savings; this means for instigating such a change, however, has not yet been promulgated. Numerous studies have come forth offering plans which indeed could reduce our consumption of petroleum fuel through modal shifts. Among the ideas proposed include: 1) gasoline rationing, which would probably eliminate some travel in addition to creating a mode shift to bus, rail, and unfortunately air; 2) a 50¢ per gallon gasoline tax, with the same result as number 1 mode; 3) an air fare surtax; and 4) tolls for interstate highway usage. These four initiatives have at least one common characteristic, they are disincentives; that is, they encourage the public not to use the inefficient. Though this is a justified approach it is a difficult one to implement because it involves penalizing certain portions of society. For example, the additional tax on gasoline would place a financial burden on the poor who are already finding it difficult to cope with today's double digit inflation. The air fare surtax would certainly bring opposition from the airline industry and certain business interests who rely heavily on this mode of intercity transportation.

Since such proposals as the four outlined above have met obstinate resistance from vested interest groups and the public-at-large, any program to encourage mode shifts to more efficient modes should, in effect, choose the path of least resistance. In the context at hand, this means fostering incentives for the efficient rather than the disincentives for the inefficient. This study focuses on such an approach. This does not mean that disincentives should no longer be considered; rather, it merely acknowledges that the obstacles to be overcome for the disincentive approach are greater than those for the incentive avenue. Given the urgent need to lessen the nation's reliance on foreign crude oil, and the potential fuel savings to be gained through mode shifting in the intercity area, the relative expedience of offering incentives for using energy efficient modes is behooved.

Fuel Conservation Potential

This section will focus on how fuel can be saved by shifting intercity passengers from cars to buses through economic incentives to bus operators and through increasing the allowed speed limit for buses on the nation's Interstate System and certain other low access arterials. On the surface it seems contradictory that fuel can be saved by going faster. This is indeed true if one considers only the consequences of such action on the mode in question. However, if increased speed limits encourage people to choose a more energy efficient mode of intercity transport than the one otherwise chosen, then the combined fuel consumption of the two modes could decline.

It is anticipated that a decrease in bus travel time, due to increased speed limits, would encourage mode shifting primarily from autos and to a lesser extent short-haul air carriers and rail in some corridors. The degree of mode shifting necessary to counter the increase in bus fuel consumption will be determined below.

A. Increased Bus Fuel Consumption per Mile at Higher Speeds

The steady-state fuel consumption of a typical bus engine is taken from Aerospace and give in Figure 1. 8/ It can be seen from the graph that fuel economy at 55 miles per hour (mpg) is approximately 7.1 miles per gallon (mpg), 5.6 mpg at 65 mph, 5.0 mpg at 70 mph and 4.5 mpg at 75 mph. Thus the amount of fuel to travel one mile is obtained by reciprocating fuel economy values:

Bus Speed (mph)	Bus Fuel 8/ Economy (mph)	Gallons Per Mile	Increase Consumption Above 55 mph Level (gallons per mile)
55	7.1	0.141	---
65	5.6	0.179	0.038
70	5.0	0.200	0.059
75	4.5	0.222	0.081

B. Fuel Consumed By an Average Automobile per Intercity Mile Traveled

The Department of Transportation reported an average of 13.94 miles traveled per gallon of fuel for passenger cars in 1977. 4/ Assuming the highway fuel economy portion of this value is 20% higher, then the average car on the road in 1977 traveled approximately 16.7 miles per gallon of gas; an equivalent of 0.060 gallons per mile.

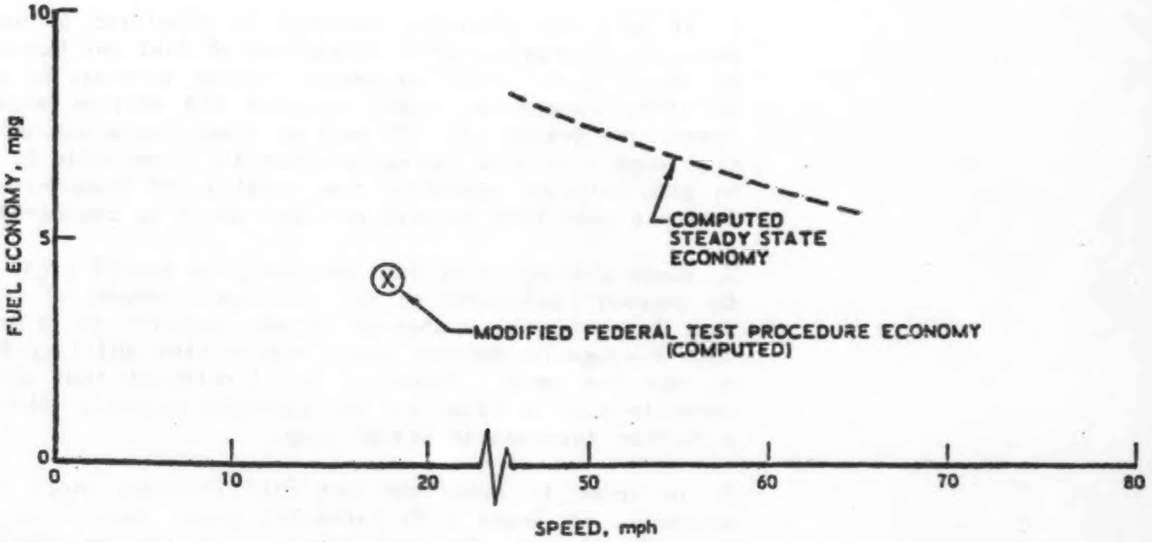


FIGURE 1 BUS FUEL CONSUMPTION

C. Extent of Mode Shift (Auto to Bus) Needed to Counter Higher Fuel Consumption at Higher Bus Speeds

The amount of mode shifting that will be induced by each scenario is difficult to assess at this time. However, one study done by United Technologies indicated that a 10% reduction in bus travel time would result in a 0.75% decrease in energy consumption. 9/ By comparison, the 65, 70, and 75 mph scenarios would reduce cruising time by 18%, 27%, and 36% respectively; the actual reduction in travel time would vary from route-to-route but should approach these values. Thus, increasing allowed bus speed limits should result in significant energy savings.

From the discussion in the previous two sections, the following conclusions can be obtained:

1. If only one intercity car-mile is displaced by each 65 mph bus-mile, approximately 0.02 gallons of fuel per bus-mile would be saved (i.e., a 2.4 passenger average increase in each bus). In 1977, commercial buses traveled 605 million miles on the Interstate System. 4/ If each of these bus-miles were associated with a shifted car-mile (that is, 1 car-mile is displaced by each existing bus-mile) then roughly 299 thousand barrels of fuel per year (789 barrels per day) would be conserved.

2. Since the amount of fuel necessary to propel a car at 55 mph is roughly equivalent to the additional amount of fuel necessary for a bus to cruise at 70 mph compared to 55 mph, no net fuel savings or penalty would result from shifting 1 car-mile to the bus mode. However, the likelihood that more than 1 car-mile will be displaced per existing bus-mile increases with a further decrease in travel time.

3. In order to lower the net fuel consumed under the 75 mph scenario, at least 1.35 car-miles would have to be displaced from the highway for each bus-mile on the Interstate System.

There is also the probability that passengers drawn to the bus mode, due to the potential reduction of travel time, will choose the bus on subsequent non-high-speed routes. This carryover phenomenon would be due to the acclimatization of new customers to the bus environment. To the extent that such carryover takes place, even greater amounts of fuel can be saved.

D. Fuel Savings Potential

If this initiative could result in 10% of the intercity automobile passenger-miles being shifted to bus, then about 180,000 barrels per day of fuel could be saved (Assumes: with improved bus load factor, that bus energy intensity per passenger-mile is 1/5 that of automobiles). If this initiative could result in the intercity bus load factor increasing from .42 to .72, then the existing bus fleet could handle a 1.5% shift in passenger-miles from automobiles to buses. This would result in about 26,000 barrels per day fuel savings.

Cost to Implement

The major cost of implementing a higher bus speed program would be in the additional fuel necessary in the bus mode. These costs are presented below:

Bus Speed (mph)	Fuel Cost * cents/mile	Increase Cost Above 55 mph Baseline (cents/mile)
55	14.1	--
65	17.9	3.8
70	20.0	5.9
75	22.2	8.1

---

* Fuel costs based on $1.00 per gallon. 10/

The additional operating cost will be offset by the increased patronage, due to mode shift. Given an average bus fare of six cents per mile, 10/ a per bus increase of only one passenger will more than pay for the additional fuel costs under the 65 and 70 mph scenarios. An increase of 1.35 passengers per bus would be needed to offset these costs under the 75 mph case.

The need and additional cost of more buses would probably be welcomed by the bus operators and the manufacturers. If the mode shift result of this initiative is just to increase the load factor, then no new buses will be needed. However, if 10% of the intercity automobile passenger-miles are shifted to bus, between 2.8 and 4.8 times more buses will be needed - depending on the assumed load factor. However, any significant increase in the number of buses will probably develop over a reasonable period.

A discussion of the costs to the Federal government of a tax credit/rebate proposal will be discussed in the implementation section.

Supply

There should be no major demand for new technology due to increasing bus speed limits on the Interstate System. Additional amounts of diesel fuel appear to be the primary impact area with regards to supply needs. As outlined previously, from 0.038 to 0.081 additional gallons of diesel fuel per interstate bus mile would be needed. This is equivalent to between 23 and 49 million gallons of additional diesel fuel per year. However, a greater magnitude of gasoline will not be consumed due to mode shifting to bus from auto. Thus the net demand for fuel should not increase. Refineries will, of course, need to adjust their facilities to allow for these changes, but such modifications are already planned since the demand for diesel fuel in years to come has already been projected to increase.

Depending, of course, on the magnitude of the demand for additional buses, the existing capabilities of the affected engine and coach manufacturers could be strained or exceeded. However, over a three to five year period the industry should be able to respond even to the highest demand.

Impacts

As delineated earlier, the busing industry should be the beneficiary of additional revenues due to this initiative, and the ensuing patronage increase. Such an impact comes at a time when the busing industry needs to renovate its facilities and fleets. The specific proposal is discussed in the implementation section.

Of paramount concern in this program are its safety implications. A mix of vehicle speeds, such as the one envisioned where automobiles are cruising at an average 60 miles per hour,1/ while buses cruise at higher speeds, has an ominous portent. For this reason, the increased speeds should only be allowed on the Interstate System where average speeds are fairly constant and any driving adjustments due to differing speeds of companion vehicles can easily be made. It has been determined that fatal accidents on the Interstate system are not a strong function of speed; but rather a function of traffic density.11/ Thus, to the extent that increased bus patronage removes automobiles from the highway, less fatal accidents would be expected.

Implementation

A. Increased Speed Limit on Interstate Highways for Buses

Given the important role of time to a potential intercity passenger, the bus mode can be made more attractive if its cruising speed is allowed to increase. Three scenarios, representing 65, 70, and 75 mile per hour speed limits for buses operating on the Interstate System are examined.

It was estimated that if each bus currently operating in the intercity theater could displace 1 additional car over the same route, then 789 barrels of fuel per day would be saved under the 65 mile per hour scenario; no net conservation or consumption penalty transpires as a result of the 70 mile per hour scenario; and up to 1.4 car-miles would have to be displaced from the highways for each intercity bus-mile in order to decrease the total fuel consumed under the 75 mile per hour scenario.

The choice between 70 mph and 75 mph is not straightforward. Certainly, the increased costs of either of these options is likely to be offset by increased ridership. The 27% reduction in cruising time obtained by the 70 mph speed limit is significant; the additional 9% reduction in going 75 mph may not promote a proportionate increase in ridership - especially when its effect on door-to-door travel time is considered. Although the safety impact is not expected to be significant, increasing the speed from 70 mph to 75 mph is likely to be detrimental, especially if the incremental mode shift is small.

B. Tax Credit/Rebate

In addition to increasing bus speed limits, Federal economic incentives to the busing industry should also facilitate passenger shifting to the bus mode of intercity travel. Action such as the recent Congressional repeal of the Federal excise tax on fuel, oil, parts and new buses was a positive step which should be continued. One option along these lines would be a tax credit/rebate administered on a per passenger-mile basis. Such an approach has an advantage over a more straightforward monetary reimbursement since bus operators would be behooved to channel the additional revenues back into endeavors that generate patronage in order to obtain a larger tax credit. (It rewards the desired performance).

Accounting for those excise taxes which were repealed, the busing industry still paid approximately $82.8 million in Federal, state, and local taxes in 1977. 12/ In that same year intercity buses accumulated 26.2 billion passenger-miles (refer to Table 1). Thus the busing industry's tax expeditures amounted to 0.32 cents per passenger-mile in 1977.

Perhaps the most appropriate way to derive a tax credit/rebate is to eliminate the government subsidy differential between the two intercity common carrier modes of aircraft and bus. Certainly the logic of preferential government subsidy to the most energy inefficient intercity passenger transport mode (aircraft) bears re-examination in light of this country's energy problems. A thorough study of the full governmental subsidy of the airlines is beyond the scope of this analysis, but the operational support of the Federal Aviation Administration and the research development support of the National Aeronautics and Space Administration and the Department of Defense are key components. Considering only that the commercial airlines pay no fuel tax, a tax credit/rebate to the bus companies for the non-federal (remaining) fuel tax would be equivalent to about 0.1 cents per passenger-mile. (Assumes: 5 mph, remaining fuel tax of 10 cents/gallon, and an average of 20 passengers per bus per mile).

If a tax credit/rebate of 0.3 cents per passenger-mile were given, and assuming that this economic incentive was sufficient to shift 10% of the intercity automobile passenger-miles to bus, then the country's fuel savings would be about 2.7 billion dollars per year (fuel at one dollar per gallon), or about 2.7 cents per bus passenger-mile. The "cost" to the Federal government for the tax credit/rebate in this situation would be about 450 million dollars per year or about 16 cents per gallon of fuel saved (Assumes: 150 x 10^9 bus passenger-miles), the cost at 0.6 cents per passenger-mile would be about 32 cents per gallon, and at 1.2 cents per passenger-mile would be about 64 cents per gallon. A tax credit/ rebate of 0.3 cents per passenger-mile should not result in a net government subsidy to the bus industry, however.

C. General

Congressional action would be required to change the speed limits for buses on the Interstate System. The busing industry can be expected to lobby for such a proposal and thus foster its implementation. Opposition could conceivably come from the modes expected to lose patronage to buses, especially the short-haul airlines. Amtrak could also expect some mode shifting but only in a few corridors. The most directly affected mode, in terms of decreased patronage, would be the automobile; but since the proposed initiative affects usage patterns rather than sales directly and since many automobile manufacturers also produce buses, there should be little opposition from the automobile manufacturers.

Since the total fuel consumed in intercity travel will decline as a result of shifting to the bus mode, the petroleum industry will find less of a demand for its products, principally gasoline and diesel fuel. The current financial stature of the petroleum industry should, however, preclude any vehement objections and ensuing lobbying efforts to prevent passage of the necessary legislation.

Recommendations

In order to encourage a shift of intercity passengers to buses, it is recommended that:

1) A 70 mph speed limit should be set for intercity buses operating on Interstate Highways, and

2) A Federal tax credit/rebate of 0.3 cents per passenger-mile be provided to intercity bus operators.

Congressional action will be necessary to allow implementation of these recommendations.

References

1/ Transportation Energy Conservation Data Book, Third Edition, Oak Ridge National Laboratory; February 1979.

2/ U.S. Federal Highway Administration, Quarterly Report, Washington, D.C., December 1978.

3/ Committee on Public Works and Transportation, Status of the Nation's Highways, p. 59.

4/ Highway Statistics, U.S. Dept. of Transportation, Report No. FHWA-HP-HS-77, Table VM-1, 1977.

5/ National Transportation Policies Through the Year 2000, National Transportation Policy Study Commission, Final Report, June 1979.

6/ Energy Efficiency of Various Transportation Modes, Transportation Research Record 689, TRB, NAS, Washington, D.C., 1978.

7/ Air Transport Association of America, Air Transport 1978, Washington, D.C., 1978, p. 32.

8/ Alternative Policies for Effecting Intercity Energy Use Reduction, The Aerospace Corporation, October 1974.

9/ Modal Shifts in Short-Haul Passenger Travel and the Consequent Energy Impacts, United Technologies Research Center for DOE, March, 1978, p. 95.

10/ Personal Communications with Wes Allen, American Bus Association, Washington, D.C., February 19, 1980.

11/ Personal Communications with Jim O'Day, Highway Safety Research Institute, Ann Arbor, Michigan, February 21, 1980.

12/ America's Most Fuel Efficient Passenger Transportation Service, American Bus Association, 1979.

IV. ECONOMIC DISINCENTIVES - A TAX ON IMPORTED PETROLEUM

Summary

This analysis investigates gasoline excise taxes as a means of reducing U.S. automotive fuel consumption. It examines the relation between such a tax and the ongoing automotive fuel economy standards program. Both the short- and long-term implications of a tax are discussed. In addition, the concept of an imported petroleum tax is developed and recommended. Savings in total petroleum consumption (both transportation and non-transportation sectors) of almost 250,000 barrels per day are expected in the near term, 500,000 barrels per day after 1985, and over a million barrels per day after 1990.

Short-Term Effects on Consumption

The economic concept of price elasticity of demand provides the most useful measure of the potential effects of an excise tax on gasoline consumption. When only small changes in price and quantity (up to 5%) are being measured, it can be understood as the percent change in quantity of a good demanded divided by the percent change in its price. When larger changes in price and demand are being measured, a more complex formula must be used;1/ but in either case it is a measure of the responsiveness of demand to changes in the price of a good. Since price and demand tend to change in opposite directions, calculated price elasticity is usually negative.

Economists have made a number of calculations of gasoline's short-term price elasticity. Short-term price elasticity assumes no change in the existing vehicle fleet, nor in work and residence patterns. The numerical value of short-term elasticity is largely a reflection of the degree to which price changes affect vehicle miles traveled (VMT). Most estimates of short-term elasticity have produced a figure in the range of -.1 to -.3. The DOE estimates a short-term elasticity of about -.2. A 1975 study by Charles River Associates produced a relatively high estimate of -.15 to -.35. In 1976 McGillivray made an estimate of -.23. Other economists opt for a more conservative range of -.1 to -.2.2/ (The use of ranges instead of single figures reflects the inevitable uncertainty of any elasticity estimate and, in particular, cases in which equally plausible alternate assumptions can be made which affect calculated elasticity). Actual price and consumption statistics for the past two years are consistent with this general range of elasticities. A calculation of elasticities based on price and consumption changes between August, September, October and November of 1979 and each of those same months in 1978 yields elasticity figures of -.19, -.20, -.15 and -.26, respectively.3/ Prices in the 1979 months were between 33 and 40 percent higher, and consumption between 7 and 10 percent lower, than in the 1978 months. Accurately estimating elasticities is more difficult than these simple calculations suggest. In 1979 sporadic shortages and gas lines strongly influenced consumption, and it is virtually impossible to separate the effect of price from the effects of unavailability and inconvenience. As an example, calculating short-term elasticities by the above method for June and July, months of physical shortage in 1979, produces figures of -.33 and -.30. These elasticity figures, higher than those calculated for later months, are almost certainly inflated by gasoline unavailability. A second source of difficulty in estimating gasoline price elasticity is the fact that in past years gasoline demand has grown at roughly 3 percent a year. Hence, when calculating elasticities from year-to-year variations in consumption and price, it is unclear whether one should measure price-induced reductions in consumption from 1978 levels, or from 1979 levels to be expected on the basis of past demand growth.

Translating estimated short-term elasticities into reduced consumption with a given tax is an instructive exercise. The tax figure most often discussed is a $.50 per gallon tax. If we assume this tax is added to an existing average pump price of $1.20, and if we use a compromise short range elasticity estimate of -.2, the result is an 8.3 percent cut in consumption, or approximately 566,000 bbl/day at November 1979 consumption levels. A $1.00 tax could lead to a reduction of 16.7 percent, or 1,132,000 bbl/day, again assuming -.2 elasticity and November 1979 consumption levels.

Comparison of an Excise Tax and CAFE Standards

A comparison of the effects of an excise tax with those of the present Corporate Average Fuel Economy (CAFE) standards clarifies the potential contribution of a tax to conservation. In essence there are two ways to reduce automotive gasoline consumption: improving the automobile fleet's fuel efficiency, or reducing VMT. The effects of the mandated CAFE standards are almost entirely upon fleet fuel efficiency. CAFE standards lower the marginal cost of auto travel and so tend to increase VMT; but at the same time the fuel economy standards raise automobile prices, hence reducing car purchases, fleet growth, and VMT. These two effects tend to cancel each other out. An econometric study by Carmen Difiglio of the DOE estimated that in 1985 CAFE standards will decrease VMT by less than 1 percent from the level they would reach without the standards.4/ It should be noted that from 1950 to 1975 VMT grew at an annual rate of 4.3 percent; the DOE projects that in the absence of conservation measures VMT will continue to grow at an annual rate of 2.5 percent between 1975 and 2000.5/ Thus, the CAFE program's lack of influence on VMT means not that VMT will be stable, but that it will continue to increase. Difiglio's forecast of 1.42 trillion VMT in 1985 with the CAFE standards represents an increase of .25 trillion VMT over the recorded 1978 level of 1.17 trillion VMT. Hence, gains in automotive fuel efficiency are required merely to keep gasoline consumption at its present level. It is worthy of note, though, that Difiglio's model assumes that real gasoline prices will rise little--by about 15 percent--

between 1978 and 1985. Current estimates of future gasoline price rises are greater than this, so Difiglio's model may overstate slightly the growth of VMT.

Gasoline excise taxes, in contrast to CAFE standards, have a substantial impact on VMT. As previously noted, short-term price elasticity measures are almost entirely a reflection of reductions in VMT (slower driving speeds and improved maintenance are other factors). Thus, CAFE standards and an excise tax are complementary, not competing, ways to reduce gasoline consumption. Estimates of the gasoline conservation resulting from CAFE standards and an excise tax are highly conjectural, but they do give a rough idea of the relative effects of these two policies. By means of economic modeling, Difiglio estimated that the current fuel economy standards will save 340,000 bbl/day in 1985, and 520,000 bbl/day in 1990 in comparison with the absence of fuel economy standards. These figures may be compared to the 556,000 bbl/day which we have calculated to be produced by the $.50 per gallon gas tax with a -.2 price elasticity. It should be noted in the tax's favor that the projected CAFE savings are gained only over the course of many years as the fleet composition changes, while the price elasticity savings are short-term. These figures must be treated cautiously, but they do suggest that an excise tax could contribute significantly to the conservation effort.

Long-Term Effects

Long-term price elasticities determine the long run effect an excise tax would have on gasoline consumption. Long-term elasticities take into account not only VMT reductions, but also changes in fleet character and composition, as well as any changes in work and residence patterns. Because of the difficulties of measuring the changes in fleet makeup and automobile technology resulting from price increases, long-term elasticities can be estimated with far less certainty than short-term elasticities. Studies have produced widely varying long-term elasticity estimates. A 1976 study by Charles River Associates for the DOT calculated a range of from -.3 to -1.0. Robert Pindyck of MIT gives an elasticity of -.8 given a ten-year period of adjustment to the new prices.5/,6/ Other economists believe long-term elasticity is not significantly greater than short-term elasticity. Difiglio, for example, gives an estimate in the range of -.2 to -.3.

It should be noted that the high long-term elasticities quoted above ignore CAFE standards. They thus measure how, in the absence of CAFE standards, the automobile fleet would change in response to higher prices. The CAFE standards in fact capture a large part of the long-term impact of a gasoline excise tax. Available evidence suggests that an excise tax cannot alter the technology of the automobile fleet as effectively as the CAFE standards. The CAFE standards are designed to force the pace of technological fuel efficiency improvement to the maximum extent practicable.

Auto manufacturers are being forced to invest heavily to re-engineer their product lines, irrespective of the current depressed market for domestic automobiles. It is unlikely that market forces could compel them to do so much, so fast. It is also true that even with a tax certain consumer segments, particularly buyers of large prestige cars, would be relatively unconcerned about fuel economy and would continue to demand very large, heavy cars. CAFE standards force these consumers to accept downsized and lightened versions of these luxury cars.

But although CAFE standards are probably a superior instrument for achieving technological and fuel economy improvements across the whole array of a manufacturer's product lines, the current levels of the standards have little effect on the mix of size classes demanded. Evidence suggests that higher gasoline prices have a strong impact on the size of these market segments. Whereas small (compact, subcompact, and imported) cars constituted 49 percent of all car sales in 1978, in January 1980 they represented more than 61 percent of the market, a substantial increase.7/ The European experience is also most suggestive. In December 1979 the median regular gasoline price in Western Europe was $2.42. Major automakers there, including Renault, Fiat, Volkswagen, and Peugeot-Citroen, all have average sales-weighted new car fuel efficiencies greater than the 1985 standard of 27.5 mpg.8/ These figures do not represent superior technologies so much as they represent a different size mix: virtually all cars are small cars by current American standards. It should also be noted that even where CAFE standards appear to do a superior job--downsizing the luxury car market, spurring technological innovation--the effect of excise taxes is not superfluous. In substantially modifying their products to meet fuel economy standards, manufacturers run the risk of losing consumer acceptance for their products. Insofar as a tax raises consumer demand for fuel efficiency in cars, it reduces this risk.

Impacts - Equity and the Use of Tax Revenues

Any effort to realize the significant conservation benefits which a gasoline excise tax potentially affords raises two related issues: equity, and the use of the tax revenues. The tax will fall more heavily on some groups than others. Different states have significantly different gasoline consumption per household. In 1975, state highway gasoline sales per household ranged from 864 gallons annually in New York to 2222 gallons in Wyoming. D.L. Greene analyzed these differences and concluded that they resulted not from extravagance, but from factors beyond the control of state residents in the short run, especially the spatial structure and urban/rural character of the state.9/ Greene's analysis further concluded that low density, high altitude states (e.g., Colorado, Idaho, Montana) which had the highest per household gasoline consumption also had the lowest short-term gasoline price elasticity: -.1. More urbanized states showed larger elasticities, ranging from -.19 to -.3. The states with the highest elasticity were warmer, more recently developed states such as California, Texas, and Florida. Thus, the problem of low density states' customary high levels of gasoline consumption per household is exacerbated by their low price elasticities; it appears that in the short run they would adjust their consumption very little in response to gasoline price increases. The net result of a large excise tax would be large income transfers from high consumption, low price elasticity states like Montana to those states with lower consumption levels and more price-elastic demand.

A gasoline tax would then have a disproportionate impact on some people, in particular rural dwellers. Many of these people just don't have the option of burning less gasoline without making major sacrifices, especially as compared to urban dwellers. Many people may not be able to afford new, more fuel efficient cars and may have to continue to drive their current cars. Gasoline taxes would drive up the demand for used small cars while at the same time lowering the demand for used large cars. Therefore, some people would be faced with the problem of having to pay a high price for a used small car while not being able to recover a substantial investment still reflected in an existing large car, which may have been purchased only within the last few years. The supply/demand situation for used small cars versus the need to dispose of large cars could pose a special dilemma for people. Presuming that it could be obtained, a new or used small car forced by high gasoline cost (due to taxes) would represent another type of compromise (sacrifice), in addition to purely economics, for those switching. Such a compromise is in the area of comfort and safety. A large car is more comfortable (especially for long trips) and generally even safer. (See the initiative, More Stringent and/or Restructured Fuel Economy Levels for Automobiles and Light Trucks).

Another "equity" objection to the gasoline tax is that it would penalize lower income groups. With a substantial excise tax, it is said, only the rich could afford to drive. These objections are not entirely without foundation. Like any excise tax, the gasoline tax is regressive; however, it is much less so than might be expected because the poor have a lower-than-average level of automobile ownership. In 1974, for example, it was estimated that whereas only 43.2 percent of the 8 million households with an income of less than $3,000 owned cars, 95.5 percent of the 9.7 million households earning $15-20,000 had cars.10/

Another result of a gasoline tax would be a significant shift of intercity travel from automobiles to aircraft. This shift appears already to be occurring due to the higher gasoline prices in recent times, and possibly due to the 55 mph speed limit. From the energy conservation standpoint, such shifting is counterproductive.

Importantly, the way in which tax revenues are used affects any assessment of the tax's equity. For example, a tax plan has been proposed which uses most of the revenues of a $.50 a gallon gasoline tax to reduce social security taxes. Since social security taxes are more regressive than the gasoline excise tax, the net result is a more progressive tax structure. An alternative would be a system of rebates. Such a rebate system could be administered at relatively low cost by using reductions in income tax withholding as a means of distributing the rebates, and sending annual or semiannual checks to non-working individuals. Conceivably, tax revenues could also be channeled to those states which pay proportionately more in gasoline taxes. This could serve to defuse political opposition.

One argument often made against a gasoline excise tax is that it would be inflationary. By itself, an excise tax would indeed be inflationary. The observed inflationary impact of the domestic oil price decontrol program is suggestive of what an excise tax alone might cause. But careful disposition of the tax revenues could greatly mitigate an excise tax's inflationary propensities. Wharton Econometric Associates has examined the impact of a legislative package consisting of a $.50 gasoline tax, a reduction in payroll and employer social security taxes, and accelerated depreciation of business investments.11/ The tax reductions would of course be financed by the excise tax revenues. According to the Wharton model, the inflationary impact of the program in its first year would be an increase in the annual inflation rate of 0.69 percent; in the second year, however, the net result would be a small reduction of 0.07 percent in the annual inflation rate in comparison to what it would be without the program. The first-year inflationary increase of 0.69 percent, it should be noted, is substantially less than the inflationary impact of the tax alone. Wharton did not calculate the inflationary impact of the tax alone, but the accelerated depreciation and social security reductions alone were calculated to reduce the inflation rate by 0.39 percent in the first year; this means that the addition of the excise tax to the other two proposals raised the calculated annual inflation rate 1.08 percent over what it would have been if only the social security and depreciation proposals were implemented. The anti-inflationary strains in this legislative package are: the reduction in business costs associated with the social security and corporate tax reductions; improved productivity resulting from investment undertaken because of the accelerated depreciation provision; and, finally, the stronger dollar associated with an expected decrease in oil imports (a strengthening dollar lowers the cost of imported goods). These forces, together with the fact that the excise tax is only a "one-shot" aggravator of inflation, cause the anticipated .07 percent reduction in the inflation rate in the second year. A revenue-neutral program of excise tax and rebates would also have little impact on the inflation rate. The reason is simple: although the tax and rebate system raises the cost of gasoline to heavy users, it lowers the effective price to light users. The system could be designed so that an average business or household could with moderate conservation break even. Thus inflationary cost increases for some are offset by cost decreases for others.

Any scheme that in one form or another rebated the tax, when considering the need to give special consideration to rebate levels among states, within the state (city versus rural dwellers), among income groups, etc., would be bureaucratic and costly to implement to even begin to address the equity problems. In addition, any rebate system that did anything other than just turn around and give the tax payers the exact tax paid back (which would nullify the conservation impact) would simply be a system to transfer wealth. The problem is that the workers of this country would be the ones to pay. The rich don't consume that much gasoline, so the low and middle income groups (the groups with the least flexibility to reduce consumption) will pay the tax which is then rebated to the poor and non-workers.

The inflationary aspects of a fuel or energy tax can also be weakened, without the need for a rebate system, by allowing for advanced planning. If people know what's coming and when, then they can make purchase decisions that reduce energy consumption (fuel efficient cars) without necessarily increasing the cost of transportation. If a large tax is imposed immediately, then more imported cars will be sold since the domestic auto industry has not yet even developed the production capacity to handle today's demand for fuel efficient cars. The wisdom of this country encouraging (through a large immediate gasoline tax) the purchasing of imported vehicles (at about $6000.00 each) to reduce imported petroleum (each imported vehicle saving 100-200 dollars per year in imported petroleum) should be examined closely.

An Alternative and Recommendation

An alternative to a gasoline tax exists which has most of the advantages of the gasoline tax, but without many of the serious consequences. The option would be to just increase the price of petroleum and let the marketplace force the reduction in consumption where the most economical alternatives exist. First, the non-transportation energy consuming sectors clearly have economically attractive energy alternatives to petroleum. Perhaps the only real exception is the chemical industry; however, the chemical industry use of petroleum is a small fraction of the non-transportation petroleum use. Even in residential space conditioning, the real option exists for people to insulate their dwellings to reduce energy consumption, and these measures can be taken without making sacrifices in comfort or life-style changes. In addition, the energy elasticities for many non-transportation energy consuming elements are similar to the price elasticity of gasoline demand.12/

Even within the transportation sector, mode shifting would occur in the direction of the most energy efficient means of moving people and goods. Certainly, the price of gasoline would go up but not to the same extent as would be necessary with a gasoline tax that brought about the same degree of petroleum conservation.

In particular, a petroleum tax without rebates should be imposed on imported crude, with a phase-in schedule sufficient to minimize the inflationary impact. Taxing the imported crude would have all the petroleum tax advantages previously mentioned plus would have the additional advantages of reducing our dependency on foreign oil and its inherent national security implications. Perhaps more importantly, it would stimulate domestic energy production. Exploration and production of existing fuels and the development of alternative fuels based upon domestic energy sources would be stimulated directly and significantly by a tax on imported crude.

Specifically, it is recommended that a tax on imported petroleum be implemented as follows: $10/barrel as soon as possible, $20/barrel by 1985, and 100 percent of the cost of the oil by 1990. This tax would represent only about $0.12 per gallon increase in the cost of gasoline in the near term and only about $0.25 per gallon increase in the price of gasoline in 1985. Yet, such a tax would be sufficient to stimulate aggressive development of domestic alternative fuels while at the same time imposing moderate pressure to conserve petroleum in the most cost-effective manner possible.

It is expected that with an overall elasticity of about -.2, this initiative will cut total consumption by almost 250,000 barrels per day in the near term, about 500,000 barrels per day by 1985, and very roughly about 1.3 million barrels per day by 1990. It should be noted that roughly half of the projected reduction in consumption would come from non-transportation petroleum consumption areas, and that much of the transportation reduction may in fact more appropriately be credited to the CAFE standards (or targets). In any case, the transportation reductions should not be double-counted. Perhaps the most appropriate way to view the relationship of this initiative to the new car efficiency improvement initiative is to consider this tax as modest pressure to help assure that the public will indeed purchase the more efficient vehicles.

References

1/ The % change in quantity demanded per 1% change in price formula provides a reasonable approximation of elasticity over large observed changes in price or quantity only if % change in calculated using the average of initial and subsequent prices and the average of initial and subsequent quantities. For example, if price changes from $.50 to $1.00, % change in price is $.50/$.75, $.75 being the average of the initial and final price. Using the initial price or the initial quantity alone as the divisor to calculate percent change introduces serious distortion. If price increases 100%--say from $1.00 to $2.00--and consumption in response falls by 50% from 200 units, the true elasticity is -1; calculating % change with initial prices and quantities alone, however, produces an inaccurate elasticity estimate of -.5.

2/ Charles River Associates, Price Elasticities of Demand For Transportation Fuels, Cambridge, May 1976, p. 51.
R.G. McGillivray, "Gasoline Use by Automobiles," Transportation Research Record, 1976, 561: 45-56.
Conversations with D.L. Greene and Carmen Difiglio, DOE.

3/ Price and consumption data drawn from DOE, Monthly Energy Review, January 1980, pp. 36, 83.

4/ Carmen Difiglio, "Methodology and Analysis of Ways of Increasing the Effectiveness of the Use of Fuel Energy Resources: Increasing Automobile Fuel Economy Via Government Policy," Paper presented to the U.S.-U.S.S.R. Joint Energy Committee: Information and Forecasting, December 1977.

5/ Oak Ridge National Laboratory, Transportation Energy Conservation Data Book, third edition, February 1979, p. 3-16.

6/ Robert Pindyck, The Structure of World Energy Demand.

7/ Transportation Energy Conservation Data Book, p. 1-42, Automotive News, February 1980.

8/ Automotive News, Janaury 28, 1980.

9/ D.L. Greene, "State Differences in the Demand for Gasoline: An Econometric Analysis," Energy Systems and Policy, Vol. 3, No. 2, pp. 191-211.

10/ Transportation Energy Conservation Data Book, pp. 1-88.

11/ Testimony of Lawrence R. Klein and R. Jeffery Green of Wharton Econometric Associates, Inc. before the Committee on Budget, U.S. House of Representatives, February 6, 1980.

12/ Hannon, Bruce, Herendeen, Robert A, and Penner, Peter, "An Energy Conservation Tax: Impacts and Policy Implications", A Report of the Energy Research Group of the University of Illinois, July 1979.

V. ALTERNATIVE FUELS

Summary

The alternative fuels examined were those potentially available from renewable sources - methanol, ethanol, and hydrogen. The potential of producing methanol and hydrogen from coal as an interim or supplemental measure was also examined.

In the long term (past 2000), methanol and hydrogen from coal and biomass both (one or the other or in some combination) appear to have the potential to provide a significant part of the nation's liquid fuel requirements - about 5 million barrels per day gasoline-equivalent from renewables and about 4 to 8 million barrels per day gasoline-equivalent from coal. In the short term, production of either of these two fuels is potentially greater than that of syncrude from coal or oil shale on an energy basis.

The situation for ethanol is quite different. Extensive Federal commercialization support of ethanol production from grain is not recommended. For corn, only 5 percent more energy is obtained than is consumed in producing ethanol from the best current process. Even ignoring the energetics, the long term production potential for ethanol is less than one-twentieth that of methanol or hydrogen. Thus, there is no hope that ethanol from grains or sugar crops could ever replace gasoline or diesel fuel. At best, it could be used as a gasoline extender, for which it is being used today.

When the potential increase in efficiency of methanol engines is taken into account, the methanol route (from coal) appears to provide more useful liquid fuel energy than producing synthetic crude. While the current cost of producing methanol (or hydrogen) from biomass appears to be more than that from coal, the effect of real increases in coal prices relative to wood and municipal wastes will likely narrow the margin in the near future and possibly reverse it. Thus, methanol from coal appears to be at least as viable as syncrude from coal or shale in the near term. Methanol from biomass appears to have a definite long-term edge over either fuel from coal or shale due to its more stable raw material costs and renewability.

The capital outlays for methanol production capacity are large; the current estimate is slightly less than $20 billion (1980 dollars) per million barrels per day gasoline-equivalent. However, this is somewhat less than the capital estimates for synthetic crude from coal or oil shale. It now appears that methanol (on an equal energy basis) could be produced from coal, and soon from renewables, at a price competitive with gasoline derived at current (1980) imported oil prices. In the future methanol, if imported oil prices continue to rise in real dollars, should become significantly less costly than gasoline or diesel fuel.

In the area of motor vehicle usage, there do not seem to be any problems with any of the fuels which could not be overcome. Ethanol-gasoline blends can be used in existing engines. However, methanol-gasoline blends can experience phase separation. Engines running on pure methanol (or methanol-water mixtures) would not have this problem and are projected to show a 20-35 percent increase in thermal efficiency over engines running on gasoline. These methanol engines would require some material changes to combat corrosion and other modifications to allow cold-weather operation, but these problems appear to be solvable. Finally, hydrogen-fueled engines have some definite advantages (especially in the area of emissions), but the one problem yet to be solved is fuel storage. Current fuel storage systems are heavy, but this too should be solvable in the long-term.

Ove-all, methanol appears to be a very viable near term alternative, with at least the same potential as synthetic crudes, and should be getting at least equal commercialization support. In the long-term, both methanol and hydrogen appear to be fuels which would be practical to use and available from renewables as well as coal. The environmental hazards of switching to methanol or hydrogen appear to be significantly less than those of synthetic gasoline or diesel fuel, and being available from renewables should be a definite advantage over those alternatives requiring large amounts of coal and shale in both the short and long term.

Background

The U.S. now imports about half of its crude oil. Excluding severe rationing, conservation measures cannot in the short term reduce demand to a point where imports are not needed. Even very optimistic estimates of future domestic oil discoveries show that domestic production will not be able to match expected demand.1/ Even with these optimistic discoveries, production will peak again by 1990 and begin to decrease.1/ Since transportation accounts for the great majority of the nation's crude oil consumption, alternative sources of transportation fuels will be needed to remove the need to import oil.

A number of alternative fuels and their sources are now being considered, including synthetic gasoline, diesel fuel and broadcut fuel from coal and oil shale, ethanol from grain, hydrogen and methanol from coal, and hydrogen and methanol from wood and municipal wastes. Of these alternatives, the most attention has been given to synthetic hydrocarbon fuels from coal and oil shale. Indeed, the great majority of research monies are being expended in this area. While definitely having significant potential, the sources of these fuels are themselves finite. Many figures are available demonstrating the immensity of U.S. coal and shale reserves, yet vast areas of land would have to be displaced to mine these sources. Also, the use of coal to supply liquid-fuel needs will have to compete with the increased use of coal for electric power generation and other needs. This study will take a different direction and focus primarily instead on fuels derivable from renewable resources, such as grain, wood and municipal waste. These sources have the potential of providing fuels far into the future without reducing the nation's finite reserves of energy and chemical fuel stocks.

The specific fuels examined will be methanol, ethanol, and hydrogen. Methanol and hydrogen are readily derivable from wood products, municipal wastes, or other organic matter. Ethanol is primarily derivable from grain or sugar crops (i.e., starch and sugar). In addition, production from finite resources, such as coal, will be considered as an interim measure until production from renewable sources can take over, or to supplement that available from renewables. When possible, comparisons will be made to the production of synthetic hydrocarbon fuels from coal and shale.

This study will attempt to address the primary factors which would affect the decision to produce a given alternative fuel. The first aspect discussed will be the potential to conserve energy. With this initiative, unlike most of the others, the primary goal is not to conserve fuel in an absolute sense, but to conserve those fuels in short or tenuous supply. Switching to methanol or hydrogen may save some fuel, if their use raises the thermal efficiency of the engine(s) used. However, the prime goal of switching to alternative fuels is that they will reduce the nation's dependence on imported oil. Thus, of prime interest here is the amount of imported oil displaced by the use of any particular alternative fuel.

The second section will examine the cost of producing and using any of these alternative fuels. Here, not only is the cost of producing the fuel important, but also the capital investment required, the cost of modifying vehicles and the increased or decreased costs of operating the vehicle.

Third, the ability to convert the nation's vehicles to use these fuels will be examined. The use of alternative fuels as mixtures with gasoline or alone may require modifications to vehicles and engines. Both the retrofitting of existing vehicles and the design of new vehicles will be addressed, as well as whether or not the time necessary to implement this technology would be the critical path item or not.

Fourth, the safety and environmental impacts of using these alternative fuels will be examined. Differences in toxicity and physical properties between these fuels and conventional fuels could increase or decrease the direct public health hazards, and the environmental hazards of spills. Also, the source of the alternative fuel definitely impacts the effect that gathering the raw materials has on the environment. Also, the emissions of motor vehicles using these fuels could be markedly different than when using petroleum-derived gasoline and diesel fuel and this must be addressed.

The final section will contain recommendations on future action with regard to alternative fuels.

Conservation Potential

The primary conservation potential of alternative fuels lies in their ability to replace fuels derived from crude oil, which is in tenuous supply. The potential of an alternative fuel depends on 1) the amount of the alternative fuel that could be produced, 2) the amount of petroleum fuels used in obtaining the alternative fuel and 3) the increase or decrease in the thermal efficiency of the engine operating on the alternative fuel.

A. Production Potential

The production potential of any alternative fuel depends on three factors: the availability of raw materials, the conversion efficiency, and the production capacity of conversion plants. These factors will be examined for each fuel.

The sources of methanol and hydrogen are essentially the same, while the sources of ethanol are usually different. The process of producing methanol usually involves a synthesis gas made up of carbon monoxide and hydrogen.2/ At this point, rather than reacting the two compounds to produce methanol, the addition of water and the appropriate operating conditions can produce additional hydrogen. Currently, most methanol and hydrogen is made from natural gas.2/ However, natural gas will soon be in short supply and will not be available over the long term nor for the tremendous increase in methanol (or hydrogen) production necessary for methanol (or hydrogen) to be used as transportation fuel. The future sources of methanol and hydrogen will likely be wood products and municipal waste and sewage, which are renewable, and coal, which is not renewable.3/ For the longer term, hydrogen can be produced from any energy source, including direct solar and nuclear (fusion).

The sources of ethanol are usually grains and sugar crops.3/ This difference arises because ethanol is usually produced by the fermentation of sugar and starches. Methanol (and hydrogen) are produced via partial oxidation of the raw materials with subsequent conversion of the reaction products (hydrogen and carbon monoxide).

The potential availability of renewable fuels depends on the allocation of the various raw materials to the production of a specific fuel. The primary renewable fuel sources are food processing wastes, grains, sugars, wood, agricultural residues and municipal solid wastes. It appears that it is more efficient to produce ethanol from the first three sources, and more efficient to produce methanol from the latter three sources.4/5/

Allotting food processing wastes, grains, and sugars to ethanol production then, the maximum projection of ethanol would be

7.2 billion gallons per year in 1990 and 12.2 billion gallons per year in 2000.4/ It should be noted that only the land not needed for food production has been included in determining grain and sugar production. These two production figures are equivalent (in energy) to 330,000 (in 1990) and 560,000 (in 2000) barrels per day of gasoline. The latter figure would represent 2.2 percent of total projected U.S. transportation energy use in 2000.

The potential production of methanol from renewable sources is much larger. By 1990, the maximum production of methanol from wood, agricultural residue and municipal waste is projected to be 126 billion gallons per year.4/ By 2000, this figure increases to 155 billion gallons per year.4/ These figures are equivalent (in energy) to 4.1 (in 1990) and 5.1 (in 2000) million barrels per day of gasoline. Again, the latter figure would represent 35 percent of total U.S. transportation energy use in 2000. Process conversion efficiencies to methanol are estimated to be about 58 percent for wood and agricultural residues, and about 46 percent for municipal wastes.3/4/

The conversion technology for the production of hydrogen from renewables follows more closely that of methanol than that of ethanol. Thus, it is likely that the renewable sources allotted to ethanol production would remain there even if the production of hydrogen was an alternative. However, with changes to the water-gas shift stage of the methanol process, hydrogen production could be maximized rather than a carbon monoxide-hydrogen mixture which is optimum for methanol production. As will be seen below, the conversion efficiencies of coal to hydrogen and coal to methanol are approximately equal (on an energy basis). Extrapolating this to the same processes based on renewable sources would mean that the production potentials quoted above for methanol also apply to hydrogen (on an energy basis).

While the production of methanol or hydrogen from renewables was being implemented, the supply of either fuel could be supplemented in the near or long term with coal-derived fuels. The Stanford Research Institute (SRI) has estimated the "maximum credible" production levels of both syncrude and methanol from coal and this is shown in Table 1.6/

Methanol production from coal is not limited by technology or raw material supplies, but is limited by capital availability and plant construction lead-time.6a/ Provided the availability of sufficient capital, the methanol production levels for 1995 and 2000 in Table 1 could easily be doubled. The limiting factor for methanol use is not production capability, but rather consumptive capacity. Motor vehicles must be significantly modified or initially produced with the ability to burn methanol; therefore, the phase-in of a methanol-tolerant fleet appears to be the limiting factor for methanol use.

As can be seen, potential methanol production (in terms of

Table 1

Stanford Research Institute Maximum Credible Implementation Scenario for Synthetic Liquids Fuels Industry 6/

	1985	1990	1995	2000
Syncrude from Coal (10^6 Barrels/Day)	0.09	0.50	1.50	4.00
Methanol from Coal (10^6 Barrels/Day)	0.6	2.0	5.0	8.0 a/

---

a/ Energy content of a barrel of methanol is roughly equal to a half barrel of syncrude.

gallons) is always larger than that of syncrude. While methanol, by volume, only contains half the energy of syncrude, the use of methanol can increase the thermal efficiency of motor vehicle engines by up to 15 percent (see later discussion). Thus, the production volumes of syncrude should be multiplied by something like 1.75 to place them on the same basis as methanol. Even with this factor however, the projected production capacity of methanol is larger than that of syncrude. By 2000, using SRI projections, methanol from coal could supply 18 percent of U.S. total oil requirements and 34 percent of U.S. requirements for oil not met by domestic crude production (total requirements taken from 6/).

The production levels of hydrogen from coal are about the same as those of methanol (on an energy basis). An examination of two tested hydrogen-from-coal processes shows an energy conversion efficiency of 57-60 percent.8/9/ This is in the same range as that for processes producing solely methanol from coal.6/10/10a/ Processes producing methanol and other usable by-products (e.g., SNG) are capable of higher efficiencies, in the 69-75 percent range.2/10a/ The Department of Energy and the Congressional Research Service have recently estimated the conversion efficiency to produce methanol from coal to be 79 percent.6a/ Given this, the potential production levels of the two fuels should be about the same. Thus, by the year 2000 either fuel (based on coal and renewables) has the potential to replace a very large portion (over 40 percent) of projected future U.S. crude oil requirements, and an even greater portion (over 80 percent) of that not projected to be met by domestic oil production. Ethanol, on the other hand, only appears to have potential as a gasoline stretcher and not a real alternative to foreign imports.

The practical availability of shale oil is difficult to predict due to its heavy concentration in western states where a short supply of water and environmental concerns could limit production. However, estimates made by the Department of Energy place potential production in 1990 at about 0.3 million barrels per day.7/ This would place the potential production of shale oil in roughly the same range as that of syncrude from coal described above. The Congressional Research Service estimates maximum production levels less than 0.20-0.36 million barrels of oil-equivalent per day by 1995.7a/

B. Petroleum Consumed in Obtaining the Alternative Fuel

Before any of these production estimates can be taken at face value, the activities necessary to produce these fuels must be examined to insure that large quantities of petroleum energy are not consumed in the process. It is most important to examine the use of petroleum fuels required by the production process as these are the fuels we need most to conserve. These fuels could be expended in growing or mining the raw materials, transporting them to the plant, consumed in the production process or in the transporting of the finished product to the market.

The critical fuel to examine under these criteria, of those available from renewables, appears to be ethanol. With ethanol production, the net amount of useful energy (liquid fuel) gained by the conversion varies greatly with the grain/sugar source but can approach only a few percent of the energy used in production. The Department of Energy has examined the energetics of ethanol production for a number of sources of ethanol.4/ For sugar cane, almost two and a half times the energy used in the process is produced in the form of ethanol. For sweet sorghum, about two times as much energy is produced as is consumed. For corn and cassava, however, only 5 and 16 percent more energy, respectively, is produced as was consumed in the process. Thus, unless the fuel used in growing and processing these last two sources can be switched to readily available fuels, such as coal or raw grains (they are now primarily liquid fuels and natural gas), the usefulness of producing ethanol may be in question.

This does not appear to be the case for the production of the other two fuels, methanol and hydrogen, from renewables. Energy required by the conversion process comes from the renewable source itself. The energy needed for harvesting (wood) and collection (wood, municipal wastes) does not appear to be a problem.5/ It has been estimated that approximatly 3-4 percent of the methanol produced would be required to transport the wood to the plant.4/ 10b/

The result for the production of methanol and hydrogen from coal is similar. All the energy required to actually convert coal to these fuels has been accounted for in the conversion efficiencies used to determine the production capacities cited previously (except for the energy required to mine the coal). Any requirements of hydrogen, steam or other form of energy has been provided by the process itself or additional coal (which would be included in the input requirements). Thus, no petroleum fuels would be needed by the process.

Energy will be required to mine and transport the coal, but if needed in a liquid form, methanol from the plant could be used. Conversion plants will likely be located at the coal mine sites to reduce coal transport costs and take advantage of the relative ease of transporting the liquid product.11/12/ Thus, coal transport costs (in terms of energy) should be very small, even smaller than the 3 percent estimated above for wood. These energy costs would also occur for the production of synthetic oil and gasoline.

Transportation of the finished product to the market will require energy, but this could also be supplied by the alternative fuel itself. This energy cost may be slightly higher than with gasoline, given the lower energy density (Btu/gallon) of methanol and the special requirements of hydrogen. However, in any event, these requirements should be small compared to the total amount of usable energy reaching the market.

C. Implementation in Motor Vehicles

The current motor vehicle fleet was designed to operate on either gasoline or diesel fuel. The adaptability of motor vehicles to accommodate alternative fuels, and vehicle design strategies of the future, will dictate the eventual degree of market penetration by ethanol, methanol, and hydrogen. Each fuel has unique properties which will determine its acceptance potential, vehicle design, and ultimately the cost of conversion.

Methanol has a lower heating value than gasoline, i.e., more net energy is liberated from burning gasoline than methanol if all conditions are held constant. By liberating 57,110 Btu's of energy per gallon burned (as compared to 111,331 Btu's per gallon of gasoline) almost twice as much methanol need be burned to provide the same amount of transportation work if identical efficiencies are presumed.13/ Other properties of methanol, however, reduce this effect by permitting greater efficiencies than gasoline. For instance, the octane rating of pure methanol is higher than that of current unleaded gasoline. Secondly, methanol can dissolve an unlimited amount of water.14/ Work has been done to characterize the effect of methanol/ water blends; such blending effectively increases the already high octane value of the fuel and allows higher engine compression ratios before "knocking" occurs. The superior lean combustion properties of methanol allow lean mixtures to be burned at compression ratios of up to 12:1,13/ resulting in better specific energy consumption characteristics than gasoline (i.e., higher combustion efficiencies).13/ Furthermore, the latent heat of vaporization of pure methanol is nearly four times higher per unit mass than gasoline (481 Btu/lb vs. 117 Btu/lb). Since a stoichiometric mixture requires 2.36 times as much mass of methanol as mass of gasoline in an equal volume of air, 9.7 times as much heat energy is removed from the air/methanol mixture as from the air/gasoline mixture when the respective fuels vaporize prior to combustion. This cooling of the air/methanol combustion charge not only provides a denser mixture (i.e., more fuel and air burned per detonation), but also permits this denser charge to be burned at a higher thermodynamic efficiency than the air/gasoline charge.14/ (Remember that the stoichiometric mixture requires twice as much methanol than gasoline in an equal volume of air.) Overall, the increase in thermal efficiency through use of methanol has been estimated to be 26-38 percent on an Otto cycle engine.15/ Measurements on engines incorporating only some of the possible improvements have shown a 20 percent increase in thermal efficiency.15/

In blends with gasoline, methanol acts as an octane raiser allowing higher compression ratios and potentially greater efficiencies. The degree of octane improvement appears to vary drastically with the composition of the gasoline used.2/ The addition of methanol to the 10 percent level has been found to improve motor octane by as little as 0-3 RON,6/ or by as much as 50 RON.2/ A similar range of improvements in research octane from 3-5 RON 6/ to 50 RON 2/ has also been found. Data has suggested, however, that due to the leaning qualities of methanol, driveability problems occur with existing vehicles,16/ and that net fuel economy (mpg, not thermal efficiency) benefits occur only with vehicles which were originally running rich, generally the older vehicles in the fleet.16/ No technical problems have arisen which would prevent the use of methanol/gasoline blends as a motor fuel, however, a "convenience" or quality problem could limit consumer acceptance. Methanol/gasoline blends, when subjected to even small amounts of water, will separate into individual components (i.e., miscibility disappears.) Less than one percent water entry at refueling or through the carburetor in the presence of humid air could result in an inoperative vehicle. (Additives have been suggested, but most are generally expensive.16/) In short, design consideration would have to be given to improving the ability of fuel tanks, fuel lines and carburetor float bowls to resist water or humidity intrusion. Cold start problems have also been extensively studied and documented, but there are already several demonstrated techniques to alleviate this problem for use with either pure methanol or gasoline/methanol blends.) (See below.)

In summary, there are no fundamental limitations to the use of pure methanol as a motor fuel. Methanol/gasoline blends will be unreliable unless the phase separation problem due to water entry is solved. As discussed below, progress has been reported in this area, however.

It should be noted that methanol and ethanol, in blends with gasoline, have been used in motor vehicles virtually as long as gasoline. Short term conversion of a motor vehicle to run on methanol/gasoline blends involves several modifications of the engine and vehicle. First of all, the necessary air/fuel ratio and the higher heats of vaporization would require carburetor and intake system revisions. Carburetors are easily recalibrated, but new intake manifold designs utilizing some type of fuel heating capability to assist cold starting may be necessary.14/ (Secondary fueling systems have been suggested as a means of assisting cold starting. Systems using ether are already commercially available for use with heavy-duty diesel engines.) Methanol also increases the vapor pressure of the gasoline to an extent where vapor lock in the carburetor at higher engine temperatures could be a problem.16/ This problem has not been reported in diesel, stratified charge, or fuel injected engines.

Methanol and methanol/gasoline blends are corrosive of several components in today's vehicles, in particular, ternplate-lined fuel tanks, magnesium and aluminum /magnesium alloys (increasingly used in later model year vehicles for weight reduction), lead, and some plastics.14/

Volkswagen, in cooperation with the West German Ministry of Research and Technology, has accumulated over 800,000 miles on 45 vehicles fueled by an 85/15 blend of gasoline and methanol.17/ Minor carburetor adjustments and replacement of corrosion-susceptible hardware were the primary changes. Addition of isopropanol to the fuel mixture not only alleviated the phase separation problems, VW claims, but in six cars tested near the Artic Circle, no problems with cold starting were encountered either.17/

Experiments with methanol/gasoline blends in New York City's police car fleet were cut short, however, by the phase separation problem. Pure methanol had been used since June 1979 in a police car equipped with a Dodge 225 I-6 engine. Parts used to modify the car cost $400,17/ and included an electric heating grid at the carburetor, an air pump for emissions, and a multiple ignition unit commercially manufactured for racing purposes. Ether injection solved cold starting problems, and driveability was good, although actual fuel economy dropped from 15 mpg with gasoline to only 7.5 with methanol. (Fuel efficiency remained the same on an energy basis, although no combustion chamber modifications were made, however, to take advantage of the thermodynamic efficiency advantages of increased octane.)17/

In summary, methanol as an extender for gasoline, (i.e., in blends) requires engine and vehicle modifications; these modifications must be significant (i.e., compression ratio increase - realistic only for new vehicles) to achieve better fuel economy with blends of 10 percent or less methanol. Higher percentages of methanol, or pure methanol use, results in a net fuel economy loss (but improved energy efficiency) due to the inherent heating value content of the fuel. The most efficient and less problematic case of methanol therefore would entail its use as a pure fuel, where new vehicles could be redesigned from the ground up to take best advantage of the increased energy efficiency (not mpg) of methanol. Methanol blended with water appears to be the best option.

Ethanol, on the other hand, is a potentially useful extender, by virtue of the fact that blends as high as 20 percent ethanol require no engine modifications (although at 20 percent ethanol driveability and cold start problems will likely be evident with some vehicles) and phase separation problems are less than with methanol. Ethanol's stoichiometric ratio with air is 1 to 9, and has a heating value 34 percent greater than methanol (11,580 Btu/lb).17/ Brazil is in the process of converting its entire motor vehicle fleet to pure ethanol, with heavy technical support from GM, Ford, Fiat, and VW.17/ Ethanol also has a higher octane rating than gasoline, allowing operation at higher compression ratios. In Brazil, use of pure ethanol in vehicles with 12:1 compression ratios has resulted in net reductions in fuel economy (mpg) relative to their standard 6:1 compression ratio gasoline-powered vehicle. Despite the fact that ethanol contains 31 percent less available energy than an equivalent volume of gasoline, increased efficiencies due to the compression ratio increase of 6:1 to 12:1 reduced the net fuel economy losses to only 10-20 percent,17/ i.e., utilization of available energy is more efficient with ethanol. Potential increases in thermal efficiency for the U.S. fleet are not as large as those observed in Brazil because most vehicles marketed in the U.S. already exhibit compression ratios of 8:1. The potential for some improvement in thermal efficiency nevertheless exists.

Like methanol, the use of pure ethanol requires some vehicle modification, but ethanol's prime attractiveness is its blendability with gasoline. Gasohol (90 percent gasoline, 10 percent ethanol) is already commercially available in the U.S. and usable in a conventional gasoline engine. In Brazil, modifications for use of pure ethanol included cold starting systems, but in general, conversion of the existing fleet to ethanol has not been a significant problem.

Work has already been performed on diesel engines which examines the multifuel-capacity of diesels. Research has indicated multifuel capacity in diesel engines equipped with a "glow-plug" surface ignition device. Both pure methanol and ethanol can be burned at the compression ratios of today's diesels.18/

Future stratified charge engines also show potential for a multifuel capacity, although little published work has been noted in this area. The lean combustion characteristics of stratified charge engines could integrate well with the leaning properties of ethanol and methanol. Fuel volatility problems and the varying combustion air requirements of different fuels present difficulties for the design of carbureted or naturally aspirated multifueled engines; stratified charge engines are more readily adaptable to a multifuel capacity due to their great flexibility in air/fuel ratios.

The last renewable fuel considered here is hydrogen, which is significantly different from methanol and ethanol. Not only is hydrogen the most plentiful element in the universe, it has the highest energy density per unit weight of any chemical fuel (56,000 Btu/lb), it is essentially non-polluting in combustion (except for the formation of oxides of nitrogen), and can serve in a variety of energy converters from internal combustion engines to fuel cells.19/ Hydrogen is also a gas at all temperatures except those close to absolute zero. Fuel storage in the gas phase involves large and heavy containment vessels. (At a typical storage pressure of 136 atmospheres, hydrogen gas in a steel container weighs 30 times as much as an equivalent amount of gasoline, and 99 percent of this weight is the container itself.) Liquid hydrogen is extremely volatile, represents a potentially insolvable problem in terms of motor vehicle safety, and requires large amounts of energy to produce. Large-scale distribution and refueling of liquid hydrogen would be very difficult.19/

Hydrogen, however, has been successfully stored at ambient temperatures in manners much safer than conventional gasoline, and at a molecular density greater than in liquid form. This storage takes place in an equilibrium chemical reaction between most metals and gaseous hydrogen to form metal hydrides. Hydrogen atoms are stored in the interstitial sites within the actual crystal structure of the metal or metal alloy. The storage metal is initially "primed" by exposure to hydrogen gas under pressure; this priming causes the metal particles to crack along their surfaces, substantially increasing the surface to volume ratio of the metal. The particles will then react readily with hydrogen. Release of the hydrogen from the hydride requires heat; the amount of heat required is determined by the particular metal. Metal hydride storage is compact and safe at ambient temperatures. Prime metals used in research to date are iron titanium and magnesium nickel. The prime drawback to metal hydrides is weight; the energy density of iron-titanium hydride is 510 watt-hours per kilogram, while gasoline is 12,880, i.e., to travel the same distance, metal hydrides weighing almost 20 times an equivalent amount of gasoline would be necessary. This is, however, competitive with the foreseeable uses of electric storage batteries for propulsion19/ and can be improved upon by using hybrid vehicles utilizing metal hydrides of higher energy densities.*

Hydrogen powered vehicles have been operated by Daimler-Benz in West Germany, and a 20 vehicle demonstration project is being planned in West Germany.19/ The utility of hydrogen fuels in an urban fleet is enhanced by the virtual absence of toxic engine emissions (see below: Impacts) and the capability of a central fueling system.19/ Furthermore, an experimental vehicle which can run on either gasoline or hydrogen has been demonstrated.19/ It has been reported that gasoline/hydrogen blends are substantially more thermally efficient than gasoline alone but research in this area is limited.19/

---

* Magnesium hydrides possess an energy density four times that of iron-titanium hydrides (2332 watt-hours per kilogram) yet require significantly higher temperatures to liberate hydrogen. These higher temperatures (about 289°C) have led researchers to shy away from magnesium hydride as a motor vehicle power source. Iron-titanium hydrides have been identified as more attractive alternatives.19/ Hybrid vehicles, i.e., vehicles equipped with both low and high temperature hydrides, have also been suggested. Start up of the vehicle would be accomplished using the low temperature hydride. Heat energy to drive hydrogen release in the high temperature hydride would then be taken from the heat exhaust gases.19/ In a sense, the high temperature hydride tank could store exhaust heat (energy) for subsequent release during refueling. If this tank were removed from the vehicle and replaced with a "full" tank when "re-fueling" became necessary, the "empty" tanks could be recharged at a central facility recovering the stored exhaust heat. This stored energy can approach one-third the energy of combustion and could substantially improve the overall energy efficiency of the cycle.

Cost to Implement

Estimating the cost of implementing any alternative fuels program is a very difficult task. Given enough assumptions, it, of course, can be done. The problem lies in the assumptions, however. Costs of producing fuels depends on raw material costs, which for some, like coal, may increase faster than those of other commodities, or of other sources, like wood, municipal waste, and grain. Also, the production costs are dependent on the processes assumed, which sometimes have not been proven on any commercial scale. Thus, some seemingly hard costs, such as estimates of in-situ production of oil from shale may turn out to be technologically infeasible and the cost estimate would be meaningless. Finally, the cost differential between the alternative fuel and imported oil is impossible to predict, as the latter may someday not be available at all and essentially have an infinite price.

Given all of these difficulties, it takes a tremendous amount of effort not only to conduct an original study, but even to examine previous studies, as many of the assumptions must be examined and adjusted to make the results comparable. Given this, only a brief comparison of costs will be given here, along with recommendations for future work.

There have been many studies of the cost of fuels derived from coal, shale, wood, grains, and municipal wastes.2/3/5/11/12/20/21/22/23/24/

The cost of methanol and hydrogen from coal appears to be less than that for either fuel derived from renewables.3/5/ However, one must remember that the price of coal is likely to rise faster than the price of renewable raw materials. One study by the Stanford Research Institute estimated that methanol from coal would cost $5-8 per million Btu (1978 dollars) depending on the type of coal and whether or not low-interest loans were made available.3/ The Congressional Research Service estimates the cost of methanol from coal to be $5.25-$10.50 per million Btu (1980 dollars).7a/ The cost of methanol from wood was $7-9 per million Btu (1978 dollars) and $10-12 per million Btu (1978 dollars) for methanol from municipal wastes.3/ These last two estimates also assumed low-interest loans were available. However, there is not a total consensus on this, as another study put the cost of methanol from municipal wastes below that of methanol from coal.2/

The cost of methanol from coal has also been compared to the cost of synthetic gasoline from coal. Two oft-quoted studies by Exxon and IGT in 1974 concluded that methanol produced in this fashion would be more expensive than synthetic gasoline.21/22/

These results have been used since by the Department of Energy and its predecessors to place the great majority of its effort in this area on the production of synthetic gasoline from coal and not on methanol.

However, more recent analyses seem to indicate that these two studies may 1) be out-dated or 2) be in error. A German study has found methanol from coal (Lurgi/Lurgi) to be much less expensive than synthetic gasoline via the Fischer-Tropsch process and slightly less expensive than that via the Consol process.12/ It should be noted that, while coal liquefaction studies appear to show an advantage over coal gasification, these liquefaction processes are not commercialized. As tends to be the case with unproven technologies, the cost estimates for gasoline (or crude oil) produced by such liquefaction processes are likely to be optimistic. The gasification processes used to produce methanol are all commercialized and the cost estimates of methanol should be quite firm. A Canadian study also concluded that the increased efficiency of methanol engines would overcome any higher costs at the pump and that the production of methanol from coal would provide more useful liquid fuel (more usable energy) than the production of synthetic crude.5/ This analysis included the option of producing gasoline from methanol via the Mobil process.5/

Even the recent Mobil analyses of their methanol-to-gasoline process tends to support the case that methanol is the least expensive synthetic fuel. They show synthetic gasoline costs from the Mobil process to be 30-40 percent less than that via Fischer-Tropsch24/ and very competitive with the cost of synthetic fuels from more advanced but yet unproven technologies (H-Coal, SRC-I, SRC-II, Exxon-Donor).10a/ (With respect to Fischer-Tropsch, the case was chosen where SNG is given a value equal to its cost via gasification.24/) However, methanol (on a thermal basis) would be even cheaper since the inefficiencies and costs of the Mobil process would be avoided. The Mobil process is at most 95 percent efficient, if all hydrocarbon products are considered,25/ and only 75 percent efficient if gasoline is the only product considered (based on 2.5 gallons of methanol being converted to one gallon of gasoline25/). Based on the distribution of capital investment,24/ the Mobil process represents 11 percent of the cost of the synthetic gasoline. Using the 95 percent efficiency and an 11 percent reduction in cost, methanol would be 41 percent cheaper than synthetic gasoline via Fischer-Tropsch and 6-14 percent cheaper than synthetic fuels produced by advanced but unproven liquefaction techniques.

Mobil recommends their process over methanol, based on the technological problems of using methanol in internal combustion engines.24/ As we have already seen, however, the technological problems of using methanol as a fuel exist, but are not insurmountable. Straight methanol fuel also offers a large increase in engine thermal efficiency. While the costs of converting today's engines to methanol may be considerable, the changes would not seem so dramatic if the vehicle could be designed from the ground up to operate on methanol. It is rarely mentioned in this area that today's vehicles will be totally redesigned in 10 years anyway, due to the need for increased fuel economy. To incorporate the necessary changes for methanol operation in this time frame would not be that difficult.

There is also the problem that the Mobil process is only 75 percent efficient with respect to liquid fuels (i.e., transportation fuels). The consequences of this point, it would seem, have not been fully addressed in the Mobil analyses. Again, the Canadian study came to the conclusion that the lower fuel cost and increased thermal efficiency of methanol would overcome the advantages of retaining our current gasoline-based system via the Mobil process.

The cost of hydrogen from coal appears to be in the same range as that for methanol. Two studies have estimated the costs at the plant to be $5-7 per million Btu (1977 dollars) using existing technology.8/9/ The same point holds here that was made earlier in the case of methanol, only perhaps on a longer-term basis. There are considerable advantages to going to a hydrogen-fueled transportation system. These advantages must be fully considered in light of potential technological advances and weighed against the costs of conversion. This has rarely been done to any great detail for methanol or hydrogen. At some point in the analyses, a problem will be raised that is said to outweigh any potential advantages, while at the same time, equally unproven and costly technology will be accepted in other areas, particularly if it leads to the status quo.

The cost of producing ethanol from renewables appears to be much greater (on an energy basis) than producing either hydrogen or methanol from renewables or coal. The same Stanford study cited above found the cost of ethanol from corn stores, cheese whey, or wheat straw to be 100-250 percent higher than the cost of methanol from wood and 50-150 percent higher than the cost of methanol from municipal waste.3/ Thus, ethanol again appears to be useful only as a short term solution to reducing oil imports which cannot be reduced any other way. As a long term solution, however, both methanol and hydrogen appear far more economical.

While the production of methanol and hydrogen from renewables appears more economical than that of ethanol, the capital outlays required are greater. The capital investment for a 1.25 billion gallon per year wood-based methanol complex (41,000 barrel per day gasoline equivalent) would be $1.4-2.0 billion (1977 dollars).5/ A single 341 million gallon per year methanol plant (11,130 barrel per day gasoline equivalent) would cost $390 million (1977 dollars) while a smaller 114 million gallon per year methanol plant (3700 barrel per day gasoline equivalent) would cost $181 million (1977 dollars).5/ A 63 million gallon per year ethanol plant (2900 barrel per day gasoline equivalent) would cost about the same per energy capacity, about $125 million (1977 dollars).5/

The capital outlays required for production of any fuels from coal would also be large. For methanol, the capital investment appears to be about $1.2 billion (1976 dollars) for a methanol plant producing 15,000 tons per day (54,000 barrels per day gasoline equivalent).1/ The Department of Energy and the Congressional Research Service project the capital cost necessary to produce the methanol equivalent of 9-10 billion gallons per year (about 620,000 barrels per day) of gasoline is $10 billion (1980 dollars).7a/ For hydrogen, the cost would be $185-288 million (1977 dollars) for a 100 million standard cubic feet/day (6,000 barrels per day gasoline equivalent) plant and $500-800 million for a 250-500 million standard cubic feet per day plant (16,000-32,000 barrels per day gasoline equivalent).8/9/ Finally, for syncrude, the cost would be in the same approximate range as that for methanol (on an energy output basis),1/ but this could vary substantially due to the many different processes being proposed and their differing outputs.

The minimum capital outlays for a 50,000 barrel per day above-ground oil shale facility has been estimated by the Congressional Research Service as $1.5 billion (1980 dollars).25a/ Additional capital would be needed for the refinery.

Impacts

The largest potential impacts of any alternative fuel program would be in the area of public safety and the environment. Of specific concern are the hazards of direct human exposure to the fuel, massive fuel spills, environmental impacts of the mining and production processes, and the emissions from vehicles using the fuels.

When considering the hazards of direct exposure to humans, methanol is the fuel that is most often discussed. The potential hazards of direct ingestion of methanol are well known.26/ However, the dangers of common gasoline are not insignificant either, and people's general comfort with the use of gasoline may be more associated with its long-term usage rather than its relative safety. Indeed the dangers of using methanol as a fuel appear to be no greater than those of regular gasoline.26/ In fact, the use of methanol may even have a net positive impact in this area with respect to our current use of gasoline.26/ While more work definitely has to be done to ensure that there are no adverse chronic effects from long-term exposure to methanol,27/28/ there appears to be no overriding concerns that would preclude the use of methanol as a fuel.

There is an important point to remember when comparing methanol to synthetic gasoline or diesel fuel. Synthetic gasoline and diesel fuel from coal or shale may be more hazardous than petroleum-derived fuels. Ames tests and other similar screening tests for mutagens and carcinogens have shown synthetic fuels to be mutagenic and possibly carcinogenic. Similar tests of petroleum-based fuels have proved negative. While no carcinogenic effect has yet been shown, some consideration must be given to the potential presence of such an effect, particularly compared to other alternative fuels without this potential.

Similar problems with ethanol are generally considered of less concern than those with methanol. Thus, since no overriding concerns appear to be present with methanol, the same should be true for ethanol. Human exposure to hydrogen should be even less of a problem due to its normally gaseous state and rapid diffusion characteristics.

Again because of its toxicity, methanol usually receives the most attention with respect to fuel spills. Methanol is highly soluble in water and, unlike gasoline, would disperse rapidly after a spill in any marine, estuarine, or fresh water habitat. This dramatically reduces the time available for clean-up. However, it also dramatically reduces the concentrations of methanol seen by plants, fish, and wildlife. An analysis has been performed to determine the impact of such methanol spills.29/ Generally, the results were very positive. Long-term impacts of spills or leaks should be of little concern as methanol is biodegradable and volatile and most of its biological effects are reversible.29/ It would only be in the immediate area of the spill where methanol concentrations reached more than one percent that appreciable impacts would occur.29/ Thus, the dangers from spills of methanol should actually be less than those of crude oil.

If methanol or hydrogen were produced from coal, the environmental impacts of mining should be the same as syncrude from coal. These may have some net benefit over syncrude from oil shale simply due to the tremendous amounts of shale that must be mined compared with coal. If methanol, hydrogen, or ethanol were produced from wood, grains or waste, there would be significant environment benefits compared to the mining of coal or shale to produce syncrude. As much of the biomass used would be waste material, such as cheese whey, waste products from wood processing and municipal wastes, their use as raw materials for fuels would remove the need for disposal in some other environmentally acceptable manner. Also, as silvacultural farms were started to produce wood for methanol or hydrogen production, these farms would convert marginal use land into cultivated areas. This should tend to make the land aesthetically more appealing. This result is the direct opposite of the result of strip-mining coal or mining oil shale, where large efforts and costs are required to reform the land after the mining is completed.

Moving on from mining to production, there appears to be no uncontrollable environmental impacts related with the actual production of methanol, ethanol, or hydrogen from either coal or renewables. Regardless of the raw materials used, the production of methanol (or hydrogen) involves medium Btu coal gasification which can be designed to have few effluents.4/ The production of ethanol via fermentation is also a very clean process and should prove no problem environmentally.

The environmental effects of widespread combustion of these alternative fuels should also be less than those of gasoline. When blended with gasoline, methanol and ethanol tend to "lean-out" the combustion mixture because of the additional oxygen in the alcohol molecule, and emissions parallel leaned-out operation of pure gasoline.30/ Results of numerous studies are varied, depending upon the degree of alcohol-related engine optimization and emission control equipment used. In general, however, exhaust hydrocarbons (HC), carbon monoxide (CO), and nitrous oxides (NOx) did not vary significantly from levels observed in later model year vehicles (i.e., calibrated for lean operation) using pure gasoline. Aldehyde emissions, however, increased significantly (20-25 percent in one methanol study16/). Most researchers believe that present technology oxidation catalysts can easily handle the additional aldehyde emissions if they prove to be a problem.31/ Evaporative emissions increase due to higher fuel volatility, and will require more effective evaporative emission control systems.33/

Pure ethanol and methanol usage produces significantly less hydrocarbon and carbon monoxide emissions.17/ Methanol in solution with water can operate at higher, more efficient compression ratios with no increase in oxide of nitrogen emissions,13/ while pure methanol has been shown to reduce nitrous oxides emissions by 33-50 percent.14/15/ Aldehyde emissions are higher than with gasoline, but as with the blends, present catalytic converter technology should be able to handle any increase.

Hydrogen fuel's primary combustion product is water, with some nitrous oxides emissions varying in amount with combustion temperature. However, water injection has been shown to effectively control nitrous oxides emissions.32/ Because hydrogen fuel is low-polluting, it is receiving much interest as a fuel for centrally-based urban fleets.19/

In short, the environmental impacts of these alternative fuels from a combustion standpoint are not limiting factors in their increased usage. In many cases, environmental benefits are achievable if alternative fuels are burned in place of gasoline.

Recommendations

1. The above analysis has shown that the near-term potential of methanol from coal and biomass is just as great as that from synthetic crude. In fact, despite the results of older studies, more recent analyses have shown methanol to be preferred over synthetic gasoline based on economics. In the long-term, the fact

that methanol can be produced from renewable sources gives it a definite advantage over any fuels solely derived from non-renewable sources. It is therefore recommended that the Federal government change its policy from primarily supporting synthetic crude programs to one which places major emphasis on methanol. It is also recommended that significant effort be made toward the development of a pure methanol engine which minimizes the cost of new materials and equipment while taking full advantage of the unique properties of methanol. There is a certain inertia which propels the development of syncrudes and hinders the development of new fuels because syncrudes would fit in nicely with existing refineries, distribution systems and motor vehicles and the new fuels would require some changes. These factors must be duly considered, but they are not overriding and should not be considered as such. Thus, a well-balanced attack on the problem of providing secure supplies of liquid fuel for this country appears to be the best approach at this time.

2. Hydrogen, as an alternative fuel, also shows definite potential, particularly for urban fleets, in the longer-term future. Support should continue to be given to its development. One opportunity which should be used to further this development is the production of hydrogen fuel for the space shuttle. Current plans call for the hydrogen to be produced from methane. This is the cheapest and most common approach currently, but this will not be the approach used for very long. While on face value it would cost more to produce this hydrogen from coal or renewables, the opportunity to develop these processes while filling a very practical need would appear to be an invaluable one. This project could provide hard commercial-scale data on the production and distribution of hydrogen from coal and renewables which could demonstrate (or not demonstrate) the feasibility of producing hydrogen from these sources.

3. While there are many aspects of alternative fuels which deserve future study, environmental impacts being one, the aspect of socio-economic benefit has not been dealt with thus far. Specifically, a study of the differences in the types of and effects on employment of the various alternative fuel programs would appear useful. It would seem reasonable to expect that a renewables-based fuel might result in more people being employed in more areas than a coal or shale-based approach. Regardless of the actual results of the study, the area is an important one, as unemployment could prove to be a problem throughout the period of transition from a petroleum to a non-petroleum based economy.

4. Given the fact that no single fuel is available to completely displace petroleum-based fuels, and that several of these alternative fuels may be marketed simultaneously, an engine capable of operation on a variety of fuels would greatly reduce refueling inconveniences due to location and supply irregularities. The commercial availability of a multifuel engine for consumer use

would also provide the market demand necessary for commercial development of production capacity for alternative fuels. For these reasons, it is recommended that strong Federal support for research in the area of multifuel engine development be given. Non-carbureted engines such as diesel and stratified charge engines appear to have the best chance to achieve multifuel capability. Specifically though, it is recommended that beginning in 1987, all new highway vehicles should be required to have methanol fuel capability, either as pure methanol or dual-fueled.

References

1/ Boik, Bruno C., "U.S. Alternatives to Motor Gasoline: Methanol or Synthetic Gasoline," Presented at the International Symposium on Alcohol Fuel Technology, Methanol and Ethanol," November 21-23, 1977, Wolfsburg, FRG, Conf-771175, UC 61, 90, 96.

2/ Hagen, David LeRoy, "Methanol, Its Synthesis, Use as a Fuel, Economics, and Hazards," Thesis, Univ. of Minnesota, December 1976.

3/ Jones, J.L., etal, "A Comparative Economic Analysis of Alcohol Fuels Production Options," SRI International, Presented at the Third International Symposium on Alcohol Fuels Technology, May 1979.

4/ "The Report of the Alcohol Fuels Policy Review," DOE, June 1979, DOE/PE-0012.

5/ "Liquid Fuels from Renewable Resources: Feasibility Study, Summary and Conclusions and Volumes A-E," InterGroup Consulting Economists Ltd. for the Government of Canada, May 1978.

6/ "Identification of Probable Automotive Fuels Composition: 1985-2000," SwRI for DOE, May 1978, HCP/W3684-01/1, UC-96, p. 4, 15.

6a/ "Gasohol: The Alcohol Fuels," A Report of the Congressional Research Service (Number IB74087), November 13, 1979.

7/ U.S. Department of Energy, Policy and Evaluation Division, Response to a request for information by Senator Johnson (LA), May 1979.

7a/ "Synthetic Fuels Corporation and Technology," A Report of the Congressional Research Service (Number MB79245), February 25, 1980.

8/ Michaels, H.J. and H.F. Leonard, "Hydrogen Production via K-T Gasification," Chemical Engineering Progress, Vol. 74, No. 8, August 1978, pp. 85-91.

9/ Pollaert, J.J., "Hydrogen from Coal," Chemical Engineering Progress, Vol. 74, No. 8, August 1978, pp. 95-98.

10/ Hokanson, A.E. and R. Katzen, "Chemicals from Wood Waste," Chemical Engineering Progress, Vol. 74, No. 1, January 1978, pp. 67-71.

10a/ Rogers, K.A., etal, "Comparison of Coal Liquefaction Processes," Prepared for DOE by The Engineering Societies Commission on Energy, Inc., April 1978, FE-2468-1.

10b/ Mundo, K.J. and H. Wehner, "The Production of Methanol from Wood, Processes, Foresting and Economics," Presented at the Third International Symposium on Alcohol Fuel Technology, Asilomar, California, May 28-31, 1979.

10c/ Nitscke, E. and J. Keller, "Aspects of Energy Conversion in the Production of Methanol from Coal," Presented at the Third International Symposium on Alcohol Fuels Technology, Asilomar, California, May 28-31, 1979.

11/ Currie, J. William, and Daniel J. Brann, "The Potential for Producing and Marketing Portable Fuels From Coal for the Transportation Sector," Battelle, June 1975.

12/ Van Hiek, Karl H. and H. Juntgen, "The Production of Motor Fuels by Coal Gasification," Presented at the International Symposium on Alcohol Fuel Technology, Methanol and Ethanol, November 21-23, 1977, Wolfsburg, FRG, CONF-771175, US 61, 90, 96.

13/ Mott, W.J. and J.P. Longwell, "Single Cylinder Engine Evaluation of Methanol - Improved Energy Economy and Reduced NOx," SAE Paper No. 750119, February 1975.

14/ "Another Look at Methanol," Automotive Engineering, Volume 83, Number 4, April 1975, p. 38.

15/ Vantine, H.C., etal, "The Methanol Engine: A Transportation Strategy for the Post-Petroleum Era," Lawrence Livermore Laboratory, March 25, 1976, UCRL-52041.

16/ Wigg, E. and R. Lunt, "Methanol as a Gasoline Extender - Fuel Economy, Emissions, and High Temperature Driveability," SAE Paper No. 741008, October 1974.

17/ Hill, R., "Alcohol Fuels," Popular Science, March 1980.

18/ Nagalingam, etal, "Surface Ignition Initiated Combustion of Alcohol in Diesel Engines - A New Approach," SAE Paper No. 800262, February 1980.

19/ Reilly, J. and G. Sandrock, "Hydrogen Storage in Metal Hydrides," Scientific American, February 1980.

20/ "Biomass-Based Alcohol Fuels: The Near-Term Potential for Use with Gasoline," MITRE for DOE, August 1978, HCP/T4101-03, UC-61.

21/ Kant, F.H., R.P. Cahn, etal, "Feasibility Study of Alternative Fuels for Automotive Transportation," Vols. I, II, III, Exxon Research and Engineering Co., June 1974.

22/ Pangborn, J. and J. Gillis, "Alternative Fuels for Automotive Transportation - A Feasibility Study," Vols, I, II, III, Institute of Gas Technology, July 1974.

23/ Adelman, Morris A., etal, "Energy Self-Sufficiency: An Economic Evaluation," Technology Review, May 1974.

24/ Lee, W., et al., "Catalytic Conversion of Alcohols to Gasoline by the Mobil Process," Presented at the IGT Symposium, "Energy from Biomass and Wastes IV," January 21-25, 1980, Lake Buena Vista, FA.

25/ Lee, Wooyoung, etal, "A Fixed-Bed Process for the Conversion of Methanol-to-Gasoline," Presented at the 1980 National Petroleum Refiners Association Annual Meeting, March 23-25, 1980, New Orleans, LA.

25a/ "Oil Shale Development: Outlook, Current Activities, and Constraints," A Report of the Congressional Research Service (Number IB74060), March 5, 1980.

26/ Moriarity, Dr. A.J., "Toxicological Aspects of Alcohol Fuel Utilization," Presented at the International Symposium on Alcohol Fuel Technology, Methanol and Ethanol, November 21-23, 1977, Wolfsburg, FRG, CONF-771175, UC 61, 90, 96.

27/ Hagey, G., etal, "Methanol and Ethanol Fuels - Environmental, Health and Safety Issues," Presented at the International Symposium on Alcohol Fuel Technology, Methanol and Ethanol" November 21-23, 1977, Wolfsburg, FRG, CONF-771175, UC 61, 90, 96.

28/ Timourian, H. and F. Milanovich, "Methanol as a Transportation Fuel: Assessment of Environmental and Health Research," Lawrence Livermore Laboratory, June 18, 1979, UCRL-52697.

29/ D'Eliseu, Prof. P.N., "Biological Effects of Methanol Spills into Marine, Estuarine, and Freshwater Habitats," Presented at the International Symposium on Alcohol Fuel Technology, Methanol and Ethanol, November 21-23, 1977, Wolfsburg, FRG, CONF-771175, UC 61, 90, 96.

30/ Crowley, A., etal, "Methanol-Gasoline Blends Performance in Labortory Tests and In Vehicles," SAE Paper No. 750419.

31/ Peflay, R.K., "An Alcohol Fuel Alternative," Mechanical Engineering, November 1979.

32/ "An Inexhaustable, Low-Cost Fuel?" Fleet Owner, February 1980, p. 147.

33/ "Gasohol Test Program," by Richard Lawrence, A Technical Report of the Environmental Protection Agency, (Number EPA-AA-TAEB-79-4B), February, 1980.

VI. POLICY RECOMMENDATIONS

This report is largely a compilation of individual conservation initiatives, each with specific policy recommendations. A reader can thus use his/her own judgment regarding the appropriate or optimum mix of initiatives for a "preferred" transportation conservation policy.

The overall recommendation of the task force is that all conservation initiatives presented herein should be seriously considered for expeditious implementation.

Following is the list of specific policy recommendations derived from this study:

1. It is recommended that an aircraft fuel economy standard be established which would apply to all new aircraft intended to fly routes of 1,000 miles or less. The standards would be computed on an average trip length of 500 nautical miles. A fuel economy standard of 70 seat miles (nautical) per gallon is recommended beginning in 1990. In addition, considering each airline's total routes of less than 1,000 miles, routes would be required to be replaced or retired at a rate of 5 percent per year between 1990 and the year 2000, and then at a rate of 10 percent per year for an additional five years until all aircraft were replaced with aircraft meeting fuel economy standards. (Congressional action required).

2. It is recommended that the states be required to rigidly enforce the national 55 mph speed limit.

3. It is recommended that the speed limit for heavy-duty vehicles on multi-lane highways be reduced to 45 mph (although 50 mph may be a more politically acceptable option), while maintaining the 55 mph speed limit on two lane highways. Both sets of speed limits should be strictly enforced. (Congressional action required).

4. It is recommended that Congress amend the Energy Policy and Conservation Act to require the implementation of a provision granting manufacturers of 1985 and later model year passenger cars an option to certify fuel-efficient passenger cars to a 70 mph highway fuel economy test, in place of the current 48 mph highway fuel economy test. To certify, those vehicles would be required to achieve the numerical standard of 1.25 times the applicable corporate average fuel economy (CAFE) standard. It is further recommended that the 70 mph speed limit be restricted to rural Interstate highways and allowed only during daylight hours, and that 70 mph certification be provided only for new vehicles after 1985. (Congressional action required).

5. It is recommended that the Environmental Protection Agency request participation of the tire manufacturers in a voluntary tire labeling program, which would be supported by an aggres-

sive Department of Energy (DOE) public information program. If the voluntary labeling program is not effective, Congress should then require mandatory labeling in conjunction with minimum corporate average tire standards (a significantly increased excise tax for the more fuel inefficient tires for heavy-duty vehicles).

6. It is recommended that the EPA request the participation of engine oil marketing companies in a voluntary oil labeling program, which would be supported by an aggressive Department of Energy public information program. If the voluntary labeling program is not effective, Congress should then require mandatory labeling in conjunction with minimum corporate average oil standards.

7. It is recommended that the EPA conduct an engineering optimization study to determine: 1) the full energy conservation potential of engine cylinder deactivation and 2) whether the environmental and safety problems associated with this concept can be solved.

8. The Department of Transportation (DOT) and EPA should encourage responsible state agencies and legislatures to include tire inflation checks (including inflation to the recommended tire pressure) as part of vehicle safety and emissions inspection programs. EPA should also encourage the adoption of fuel economy engine diagnostic procedures to be used with emission inspection programs.

9. It is recommended that the Federal government implement strong conservation measures with respect to the Federal vehicle fleet to set an energy conservation example.

10. The EPA should accelerate its efforts to close prototype-to-production shortfalls and test procedure shortfalls, to ensure that the intent of the corporate average fuel economy (CAFE) standards is realized.

11. It is recommended that corporate average fuel economy (CAFE) targets for automobiles and light trucks be established at 50 mpg in 1990 and 80 mpg in 1995. The target should be supported with the economic motivation of a fuel inefficiency tax for those manufacturers which have a CAFE which is less than the target; the tax should amount to $100 (1980 dollars) for each mpg that the manufacturer is below the CAFE target times the number of vehicles produced by the manufacturer. It is further recommended that the U.S. government set up a guaranteed loan trust fund for the domestic automobile industry during this period of major change. It is also recommended that the Federal government consider the construction of special roadways for the exclusive use of urban cars, whenever new urban road construction is warranted. (Requires Congressional action).

12. It is recommended that over a five year period, a five to

twenty billion dollar Federal grant program be implemented to permit railroads to modernize their tracks and roadbeds. Grants should be administered to the railroad companies on a per-track-mile basis. It is recommended that a nationwide weight-mileage fee program for freight trucks be established based on gross vehicle weight, maximum axle loading and mileage. (The program should be based upon structure A of Table 2, page III-21.) It is recommended that the Federal government, as an option to each railroad, offer to nationalize rail rights-of-way with no cost, long term leasing back to the railroads with no strings attached. (Congressional action required).

13. It is recommended that the Urban Mass Transportation Act be amended to require Federal funds to be distributed solely on the basis of passenger miles of service. Transit authorities should receive 7.1 cents per passenger mile accumulated by their system during the preceeding year. (Congressional action necessary.)

14. It is recommended that a Federal tax credit/rebate be established to provide an annual credit/rebate of $100 per passenger for vanpools of more than 10 miles one-way distance. For vanpools that operate from 3 to 10 miles one-way, a tax credit/rebate should be provided at the annual rate of $25 per passenger. (Congressional action required).

15. In order to promote the use of video-telephone conferences, it is recommended that a 25 percent tax credit be provided for the first year of use to new users of the system. (Congressional action required).

16. In order to encourage a shift of inter-city passengers to buses, it is recommended that: 1) a 70 mph speed limit be set for inter-city buses operating on Interstate highways, and 2) a Federal tax credit/rebate of 0.3 cents per passenger mile be provided to inter-city bus operators. (Congressional action required).

17. It is recommended that a no-rebate tax on imported petroleum be established as follows: $10 per barrel as soon as possible, $20 per barrel by 1985, and 100 percent of the cost of the petroleum by 1990. (Congressional action required).

18. It is recommended that the Federal government shift its policy from primarily supporting synthetic crude programs to one which places major emphasis on the production of methanol. (Congressional action required).

19. It is recommended that beginning in 1987 all new highway vehicles be required to have the capability either to burn methanol fuel solely, or methanol fuel as an alternate (dual-fueled).

20. The hydrogen fuel necessary for the space shuttle should be produced from coal or renewables, to take advantage of the

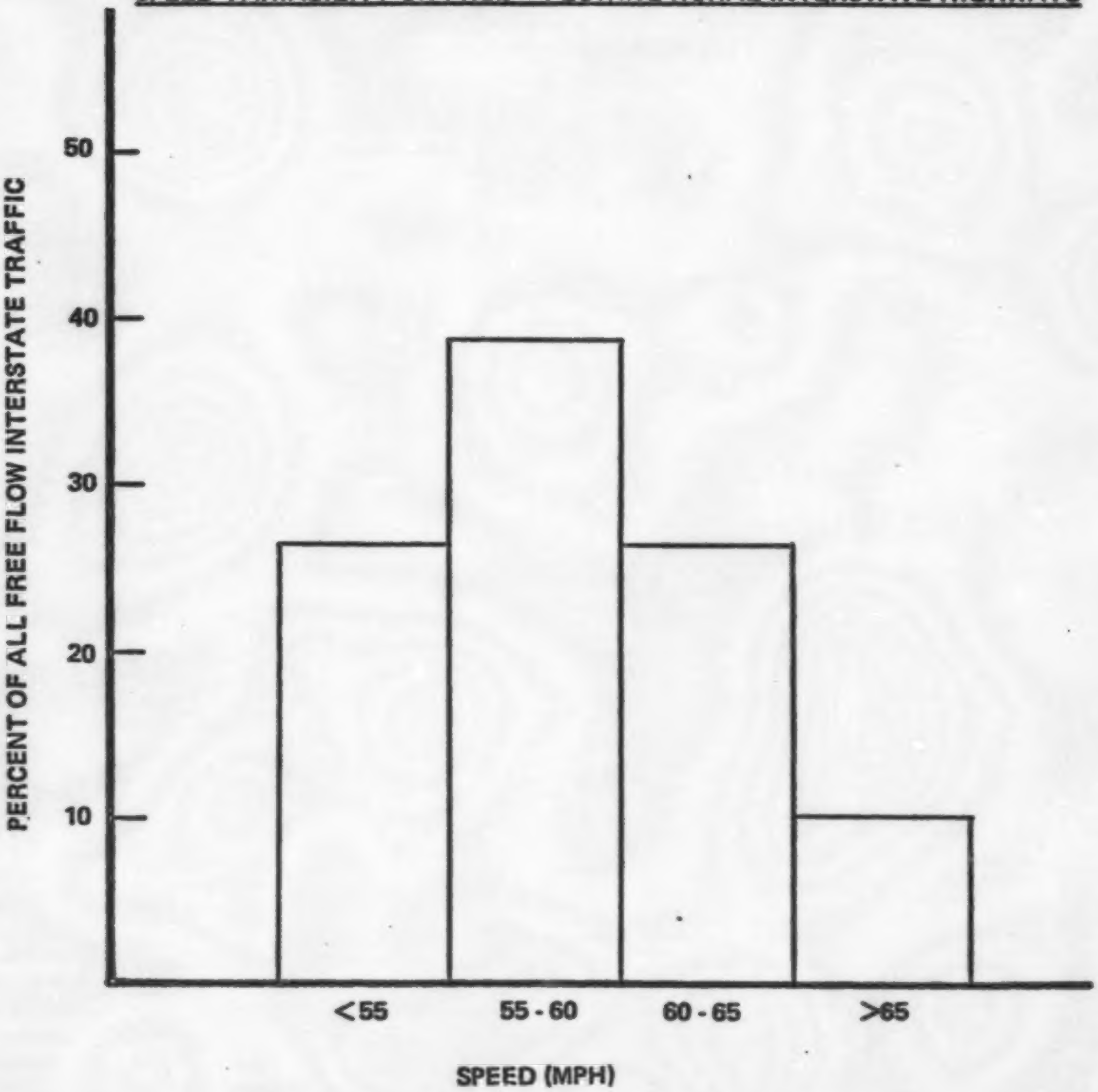
opportunity to develop these processes while filling a very practical need.

21. It is recommended that a study be conducted to determine the effects on employment associated with each of the various alternative fuels programs.

One concern which was repeatedly expressed in the review of this report was that the speed variability which would occur on the Interstate highways as a result of three different speed limits (70, 55, and 45 mph) would have a negative safety impact. While this is an important question which should receive additional study, it must also be noted that there is presently a significant speed variability on U.S. Interstate highways. Figure 1 graphically shows the free-flowing speed variability which currently exists; 26 percent of all free-flowing traffic already travels at less than 55 mph, while 10 percent exceeds 65 mph. The initiatives included herein propose that trucks travel at 40-45 mph, most passenger car traffic travels at 50-55 mph, and buses and about 10 percent of passenger cars travel at 65-70 mph.

FIGURE 1

SPEED VARIABILITY ON FREE – FLOWING RURAL INTERSTATE HIGHWAYS



SOURCE: 1978 HIGHWAY STATISTICS, TABLE VS - 1, p. 49

VII. RECOMMENDATIONS FOR ADDITIONAL POLICY ANALYSIS AND RESEARCH NEEDS

Additional Policy Analysis

All of the conservation initiatives contained in this report could benefit from additional policy analysis. In addition, initiatives should be prepared which: 1) compare the energy efficiency and government subsidy of truck transport versus rail transport versus barge transport -- the total energy from pickup of the material to final delivery should be considered as well as the infrastructure of each system, 2) develop effective means of assuring tire air pressure is maintained at manufacturer recommendation -- this is especially important in light of the significant effect of tire pressure on fuel economy and vehicle safety, the current rapid trend of removal of public air supplies from "service" (fuel dispensing) stations, the increasing pressures being recommended by vehicle manufacturers, and the difficulty of determining whether or not a radial tire has low air pressure simply by "looking," 3) develop effective means to reduce congestion at major air carrier airports during periods of maximum aircraft usage, 4) develop effective means to increase the utilization of rail piggyback service for intercity freight movement, and 5) investigate means to increase the utilization of this country's railroad system -- in particular, railroad nationalization. The latter three of these ideas are further discussed in the following sections.

Reduce Peak Period Congestion at Major Air Carrier Airports

Additional policy analysis should be conducted to determine the value (fuel savings), cost to implement, impacts, and most appropriate implementation method of reducing peak period congestion at major air carrier airports.

Reducing the peak period congestion at major air carrier airports will reduce the energy consuming holding patterns required of approaching aircraft and the idling of aircraft lined up for take-off. Delays for take-offs and landings during peak period operations at major air carrier airports is already a problem, and with deregulation is likely to be more of a problem with the likelihood of a larger number of flights being offered during these peak periods. In 1977, airline delay wasted about 682 million gallons of fuel (about 45,000 bbl/day) and in 1979 about 784 million gallons (about 51,000 bbl/day).1/ A 1979 Federal Aviation Administration report estimated that the excess fuel burned due to air traffic control delay maneuvers at Chicago O'Hare airport alone amounted to 40 million gallons in 1975 (about 2,600 bbl/day).2/

FAA forecasts for increased aviation activity in future years makes the potential scope of the delay problem even more worrisome.3/ FAA's most recent forecasts predict the following:

1) From 1979 to 1991 the airline aircraft fleet will increase from 2,623 to 3,164 aircraft, an increase of 20.6 percent;

2) The total active general aviation aircraft fleet will increase from 193,000 aircraft in 1979 to 303,800 aircraft in 1991, up 57.4 percent;

3) The number of general aviation turboprop and turbojet aircraft, which frequently compete for the same airport and airway capacity with airline aircraft, will increase from 5,900 in 1979 to 14,100 in 1991, up 139 percent;

4) The number of instrument operations at airports with FAA air traffic control service will increase 77 percent from 1979 to 1991, although the number of air carrier instrument operations at these airports will increase only 25 percent. (General aviation growth in instrument operations is expected to total approximately 119 percent.)

Superimposing even a modest part of the projected traffic growth upon the level of delays being experienced by airlines in 1979 paints a gloomy picture for the 1991 scenario unless significant improvements are made. It can clearly be seen that most of the growth in numbers of operations will come from general aviation activity rather than from airline activity. Unless significant improvements can be made in the next decade in the ability of our airports and airways system to more efficiently handle the forecast demand, avoidable delays and unnecessary waste of fuel will escalate significantly.

A recent report by the Massachusetts Institute of Technology for the Federal Aviation Administration investigated the problem of airport delays.4/ The main findings of this study are summarized in this paragraph. The weight-based landing fees used by the overwhelming majority of United States and world airports encourage additional users by discriminatory charges based on willingness or ability to pay: lighter aircraft with fewer passengers -- flights which, on the average, contribute less "transportation value" per operation -- are charged lower prices than heavier, higher-capacity aircraft. This pricing policy is appropriate at underutilized, uncongested facilities where the airport operator wants to attract as many users as possible in order to maximize revenues and recover the highest possible proportion of the initial and marginal facility costs. However, when an airport reaches full capacity, this policy worsens the congestion because a prospective user need only consider his own costs and delay which are but a small fraction of the total marginal costs that his aircraft movement causes to all other users especially if that user is a light aircraft operator. Administrative measures, such as hourly quotas or total bans on specific categories of aviation, can effectively deal with congestion problems in the short run. The "value of transportation" at a congested airport is maximized if and only if each airport user is charged full marginal delay costs. Each additional flight must pay for all the additional costs it imposes on other passengers and aircraft operators. A time-varying structure of airport usage fees based on the principle of marginal cost pricing is theoretically both necessary and sufficient to guarantee the socially optimal utilization of airport capacity. Unfortunately, serious problems arise in practice both in the numerical determination of what these pricing schedules should be and in the implementation of a pricing policy based solely on optimizing total social value without regard for revenue requirements. Perhaps the most important obstacle to implementation of marginal cost pricing at major airports is the fact that the resulting charges may be hard or impossible to bear for certain kinds of aviation. Specifically, high landing charges, when considered as a percentage of a flight's value to the aircraft operator, will have the greatest impact on general aviation, then "third-level" commuter flights, then short-haul regional carrier flights and finally short-haul trunk carrier flights. Most of the reduction in peak-hour operations as a result of marginal cost pricing is likely to come from these categories. Although this is entirely consistent with the desired effects of the pricing policy -- those who use the airport will be the ones who derive the highest value from such use -- airport and civil aviation authorities everywhere will probably be reluctant to adopt in one sudden step a practice which is so drastically different from the current system. The reasons for this reluctance may be, on the one hand, "political" (i.e. apprehension about the various forms of opposition that a policy change of this type will probably generate) and, on the other hand, uncertainty regarding the immediate and long-term effects that a completely new pricing policy will have on airport use.

Another report by the Federal Aviation Administration evaluates the impacts of airport quotas and peak-hour pricing on air traffic congestion and airport system delay.5/ It was concluded that peak-hour pricing and quota alternatives would effectively relieve aircraft congestion and delay at the 25 largest air carrier airports.

The evidence is strong that reducing peak period congestion at major air carrier airports will save a significant amount of fuel now, and that the waste of fuel will increase absent government corrective action. The available studies consistently indicate that the simple, noncapital alternatives of peak-load landing fees or airport quotas would be effective. (The basic concept of peak-load is simply the use of higher charges on aircraft during periods of high demand to control airport congestion. Theoretically, users confronted with a peak-time pricing schedule will redistribute their demand more uniformly throughout the day, with only the highest valued users receiving service during the peak-demand period, or use alternative airports as is possible for smaller aircraft.) The "problem" is simply that such an approach would represent a radical departure from the traditional concepts of free airspace and generally free access to aviation facilities and services. Specifically put, such an approach would have the effect of primarily discouraging general aviation aircraft from major air carrier airports during peak operational periods -- the objective and the institutional conflict. Once someone has a "freedom" it is difficult to take it away without strong opposition. Also, since general aviation users are the more affluent and therefore likely have significant political influence, the solution to this problem is difficult. But wait, the concept of "free" access to aviation facilities, when such access not only wasn't "free" to begin with (the public paid for it) but is now extremely costly in terms of the fuel wasted, is a concept that needs to be re-examined. There is no really good reason why the public should subsidize airport operations that increase congestion and energy consumption. General aviation aircraft can often find alternate airports that are almost as convenient as the air carrier airports.

The primary work remaining then is to determine which of the major air carrier airports are experiencing significant delays and to apply peak-load landing fees and, if necessary, airport quotas. Further, it must be determined whether the charges/quotas could be imposed and controlled by the FAA or whether new legislative authority would be needed.

References

1/ Statement of Walter A. Jensen, Vice President, Operations and Engineering, Air Transport Association of America, Before the House Committee on Science and Technology, Subcommittee on Transportation, Aviation and Communications, February 28, 1980.

2/ Halverson, Arthur G. and Jolitz, Gordon, "Terminal Area Delay and Fuel Consumption Analysis", Federal Aviation Administration Report FAA-EM-78-20, January, 1979.

3/ FAA Aviation Forecasts, Fiscal Years 1980 - 1991 (September 1979).

4/ Odoni, Amedo R. and Vittek, Joseph F., "Airport Quotas and Peak Hour Pricing; Theory and Practice", A Report of the Massachusetts Institute of Technology for the Federal Aviation Administration (FAA-AUP-77-5), May, 1976.

5/ Fromme, William R. and Swan, William R., "Airport Quotas and Peak Hour Pricing; Analysis of Airport Network Impacts", A Report of the Federal Aviation Administration (FAA-AVP-77-12), 1977.

Increased Utilization of Rail Piggyback Service For Intercity Freight Movement

Introduction

Elsewhere in this report we have advocated policies to equalize the government subsidies of the truck freight and rail freight industries, and have shown the significant fuel savings which are available if only the otherwise-expected growth in truck freight (in ton-miles) over the next two decades was shipped by rail instead of trucks (see "Shift of Freight Transport from Trucks to Rail Through the Elimination of the Government Subsidy Differential"). We think that few would argue that from an energy (or environmental or safety or total resource) standpoint practically all intercity freight shipments should occur via rail. But clearly other factors have influenced the intercity freight market to the extent that one-quarter of all intercity ton-miles are now shipped by trucks. The primary advantage of truck freight is the increased flexibility the truck has in delivering the freight once it reaches its metropolitan destination, and in its ability to get to those specific delivery points quickly and directly. Conventional rail is clearly at a disadvantage in this regard.

One possible solution to the intercity freight problem, then, is to combine the resource benefits of rail with the flexibility and delivery-time benefits of trucks. This is called "piggybacking" and involves utilizing a cargo unit which can be quickly and easily interchanged between railroad flat car and truck tractor. The two primary types of piggyback service are trailer-on-flat car (TOFC) movement and container-on-flat car (COFC) movement where the cargo container can be lifted onto and off of the truck trailer and the rail flat car by a crane-type machine.

Although loaded trailers were moved on rail flat cars as early as 1926, modern piggyback service did not begin until the late 1950's. Throughout the late 1960's and early 1970's the use of piggybacking remained somewhat constant, but in the late 1970's usage has been growing slowly but steadily. The absolute number of revenue carloadings has grown every year since 1975, and a new record for piggyback carloadings has been recorded each of the last three years. In 1979, there were 1,858,000 piggyback carloadings which represented 7.8 percent of all revenue freight carloadings.1/ In terms of total intercity freight volume, however, piggybacking accounts for less than two percent of all freight shipped.

How much of the intercity freight market could piggyback service satisfy? In 1978, approximately 2.3×10^{12} ton-miles of freight were transported by intercity shippers, with about one-quarter of this transported by freight trucks.2/ Thus, about 5.5×10^{11} ton-miles of freight were transported by truck in 1978.

We estimate that piggyback service could ultimately provide up to 50 percent of this intercity truck tonnage depending upon the specific technical approaches taken, availability of equipment, governmental incentives, etc. In the near term we are confident that piggyback service could grow at a rate fast enough to adsorb the otherwise-expected growth in intercity trucking, with the concomitant fuel savings.

Fuel Conservation Potential

We have already noted in our initiative on the relative government subsidies of rail freight and truck freight that rail is clearly more fuel efficient for intercity freight movement. There we used information from the DOE Transportation Energy Conservation Data Book to show that, in general, rail is between three and four times more fuel efficient than trucking in intercity freight transport. Just recently DOE, with funding from the Federal Railroad Administration and the Federal Highway Administration, performed a field study specifically to examine the rail piggyback versus intercity truck fuel efficiency question. Using actual fuel efficiency field data collected from the Milwaukee Road's "Sprint" trailer-on-flat car piggyback service and from intercity freight trucks operated by CW Transport, Inc., of Wisconsin Rapids, Wisconsin, collected in the Chicago-Minneapolis corridor, DOE was able to make a direct comparison of the relative fuel efficiencies. They found that the piggyback service was exactly twice as fuel efficient as the intercity trucks.3/ Though this is less of an advantage than that quoted from the DOE Data Book, it is further proof that significant fuel savings are possible from the use of rail in general and piggyback service in particular.

Impediments to Increased Use of Piggybacking

There are several reasons why piggyback service has not become more popular. They include:

1) Regulation--on some routes the pricing margins allowed by the Interstate Commerce Commission (ICC) for piggyback service have been below the costs to the railroads of providing the service.

2) Fuel Prices--when fuel was "cheap" there was not nearly the same economic motivation that there will likely be at the much higher fuel prices of the present and future.

3) Service--piggyback service almost always takes longer than direct truck service due to terminal delays and delivery and pickup times.

4) Access--only 81 cities have major piggyback service terminals, though there are an additional thousand "circus" terminals which are inefficient and subject to additional delays.

5) Tradition--truckers and railroads have rarely cooperated in the past and tend to view each other as competitors and not coordinators of service.

Hopefully the direct economic motivation of greater energy savings will spur the usage of rail piggyback service. It is also possible that the trend towards transportation deregulation will benefit piggybacking as in August 1979 the ICC began to study the possibility of a partial (or even complete) regulatory exemption for piggybacking. These factors would clearly encourage piggybacking, but would likely do so only incrementally. For large, relatively near-term increases in piggybacking it may well be necessary for major governmental programs to be enacted. Some of the possibilities that were discussed in the initiative on rail/truck subsidies, such as federal grants for rail bed rebuilding, a nationwide weight-mileage fee for intercity freight trucks, and lessening the property tax burden on railroads, would be very helpful in encouraging piggyback service, but other more piggyback-specific programs might be necessary.

Recommendations

We have not been able to extensively study the piggyback issue, thus we suggest that a program be undertaken by the federal government based on the following outline:

1) A comprehensive study of the benefits to be derived from much greater utilization of piggyback service, and of the specific issues affecting greater utilization such as terminal locations and capacities, capital requirements, governmental regulatory policies, truck/rail corporate interactions, etc.

2) A demonstration project involving railroads and trucking firms, employing state-of-the-art terminal technology, to show the economic and energy benefits obtainable from piggybacking and to set an example for intermodal cooperation.

3) Investigation and implementation of the most beneficial method for the federal government to financially assist private industry in promoting piggybacking (e.g., direct grants, loans, tax credits, etc.).

References

1/ "Railroads in the '70s - A Statistical Review", Railway Age, January 28, 1980.

2/ Transportation Energy Conservation Data Book, Edition 3, Oak Ridge National Laboratory - 5493, February, 1979.

3/ "Fuel Efficiency: TOFC vs. Trucks", Railway Age, January 28, 1980.

Railroad Nationalization

Introduction

The relative advantages and disadvantages of rail transportation have been discussed in previous initiatives. Intracity rail transit has been, and will likely be, a source of major controversy. Clearly, a modern intracity rail transit system has many advantages (speed, capacity, minimal environmental impact, ability to be underground, etc.), but the recent trend among transportation experts has been away from such systems because of their huge initial capital requirements and because the indirect energy required (for construction and equipment) makes them considerably less energy efficient than buses and, for commuting, vanpooling. Alternatively, most experts will argue that while new intracity rail transit systems cannot be justified by energy conservation alone, such systems might be justified by other considerations.

Buses have also been shown to be more energy efficient than rail for intercity passenger transportation with current load factors. Given present load factors, in fact, buses are approximately four times as energy efficient as trains, and automobiles have about the same energy efficiency as trains. The point that must be emphasized here is that there is tremendous potential for improving the energy efficiencies of passenger trains; the potential for doing so is much greater for trains than for buses, cars, or airplanes. Again, the intercity passenger train has many advantages over the intercity bus such as speed, capacity, environmental impact, comfort, etc. The extensive intercity passenger train networks of Western Europe and Japan are evidence that successful intercity passenger trains are possible. Yet less than one percent of all U.S. intercity passenger-miles are traveled via train.1/

While buses have been shown to be more energy efficient than trains for both intracity and intercity passenger transport (although trains have other significant advantages), there is no equal to the intercity freight train for general freight shipments. Freight trains are two to four times more energy efficient than intercity freight trucks (the pipeline and marine modes are very energy efficient but both are very limited in what they can be utilized for, the former by type of commodity and the latter by access to waterways). Despite this inherent energy (and total resource) efficiency, the percent of all intercity freight shipped by rail has decreased from 56 percent in 1950 to 36 percent in 1977, while trucks have increased their share from 16 percent in 1950 to 24 percent in 1977.2/ While trucks transport one-quarter of all intercity freight, they use approximately half of all energy used for intercity freight shipment.3/ A large percentage of the freight now shipped by truck could be shipped by rail, with resulting energy, environmental, and safety benefits.

The Problem

Clearly, when confronted with the significant energy, total resource, environmental, safety, and land use benefits of intercity passenger and freight (and to a much lesser degree, intracity passenger) rail transport, one must ask why the American rail system has deteriorated to a point where rail intercity passenger transport provides less than one percent of all intercity passenger trips and where there is no end in sight to further service cutbacks, and where freight trains continue to lose the most profitable freight to trucks, while the roadbeds of almost all railroads continue to deteriorate and while the number of financially viable railroads continues to decline. We have not had the time to fully analyze the complex reasons for the decline of the rail industry in this country, but we will raise some issues which future study should attempt to clarify.

We suggest that there have been at least four major reasons for the decline of the American rail system which have direct or indirect implications for government policy.

First of all, intercity rail passenger transportation is not profitable, from a private corporate standpoint, at least with the relatively inexpensive energy of the past If the experiences in the U.S. are not proof, then surely the experiences of other Western countries are — despite strong promotional support, no nationalized railway has reported a profit since 1964.4/ (It must be noted that other Western countries nevertheless provide significant intercity rail passenger service; relative to their total revenue, U.S. railroads provide less than a tenth of the passenger service common among European railroads 5/). This then raises the obvious question, who will operate an unprofitable yet socially desirable endeavor?

A second critical factor is the subsidies that have gone to competitors of railroads, both for freight and passenger transport. The relative subsidy differential between rail and truck freight has already been discussed in a previous initiative; it is manifested most directly in the taxpayer supported construction and maintenance of the highway system, inadequate highway user taxes for freight trucks, and the sometimes discriminatory state and local property tax assessments on rail property. In passenger transport, automobiles and buses have likewise benefitted from the highway system and air travel has benefitted from a host of governmental programs.

A third factor has been the lack of sound, coordinated transportation policies for this country. Again, the experiences of other Western countries are instructive. Railroads in many European countries have been instruments of national policy for 50 years or more. Transportation policies and systems have been highly coordinated, with railroads given central roles, reflected in part in intermodal coordination and the division of markets.

For example, many countries prohibit intercity buses on lines which might compete with rail services.6/ Inherent in these types of policies is the realization that rail competitors, such as autos, trucks, buses, etc., are much more flexible than trains in adapting to changes in demand and thus might unfortunately negatively impact rail's survivability in a volatile, "free" market situation. This planned transportation system in European countries contrasts sharply with American practice, which has assumed that the sum of actions of individual transportation firms acting in their own interests would satisfy a national transportation interest not defined in any stated plan or set of objectives.7/ This assumption ignores the experiences of certain cities (Los Angeles is probably the best known case) which had their urban trolley lines purchased by major auto, oil, and tire companies, allowed to deteriorate, and replaced with buses, in the interests of those companies to encourage automobile and bus usage. (In March 1949, General Motors, Standard Oil of California, and Firestone Tire Company, among others, were convicted in Chicago Federal Court of having criminally conspired to replace electric trolleys with buses.)8/

Related to the lack of a coordinated transportation policy has been the lack of any far-sighted land-use policies. Government housing programs (VA, FHA, etc.) made it increasingly possible for families on modest incomes to acquire suburban single family homes. Federal, state, and local taxation policies (e.g., accelerated depreciation) encouraged industrial plants to suburban locations as well. These policies, in concert with (and influenced by) the construction of the Interstate Highway System, were primary causes of the low-density housing patterns we find in American metropolitan areas today, which make a successful rail passenger system much more difficult.9/ To a lesser degree, the spotty locations of manufacturing facilities make rail freight a more difficult proposition as well.

The Response

To date the response of American government to the problems of the railroads has been too indecisive and inadequate to assure their future survival, if a viable railroad system is to be a national goal. A basic tenet has been to step in only as a last resort and then to minimize government involvement. Any aggressive proposal to revive the railroads by government takeover, for example, is labeled by some as "socialistic" and any attempt to improve the position of private carriers is "private enrichment" at the expense of the taxpayer. Amtrak, finally organized by the Federal government when the intercity passenger train was threatening to become extinct, had its route mileage reduced from 27,000 to 23,000 miles and five lines discontinued in 1979, just as train ridership was increasing because of escalating fuel prices. It is interesting to note that Amtrak is criticized for operating at an annual deficit of less than $1 billion while taxpayers provide $7 to $8 billion annually (in addition to what users provide) to the Highway Trust Fund. Yet there is little likelihood that many people will leave their cars and utilize Amtrak until large amounts of money are used to improve Amtrak's road beds (owned predominantly by private railroads) and rolling stock.

An alternative way of handling the American rail system would be the Western European experience — full nationalization, or public ownership and operation of the nation's rail system. Inherent in the idea of nationalization is the belief that if left to private economic forces, society will not develop the optimum rail system. One might conclude that from a societal (as opposed to a corporate) standpoint rail travel is profitable (due to "external" societal advantages which might not accrue to a corporation such as less environmental impact, less reliance on imported oil, greater personal mobility, greater safety, more jobs, etc.) even though it has to be subsidized. Public ownership would also facilitate solutions to the other problems besides profitability mentioned above (differential subsidies, lack of transportation planning, etc.)

Nationalization would provide the opportunity for the following benefits:

1) Would take the decisions regarding railroad investments out of the hands of private firms (whose primary responsibilities are to shareholders) and shift them to public officials, who can make decisions involving considerations other than simply profitability.

2) Provides a means whereby government funds can be applied towards fixed plant maintenance and improvement without the risk of enriching private property owners.

3) Removes major legal and financial obstacles to the consolidation and realignment of various railroad lines.

4) Provides an acceptable means of removing the state and local property tax burden from the cost of operating the railroads.

5) Would enable the government to determine the uses to which outdated rail property could be put.

Arguments against railroad nationalization include the following:

1) The large cost to the Federal government of purchasing the railroads.

2) The cost of railroading might rise due to the intrusion of politics and "bureaucratic" decision-making into management decisions.

3) There is no reason to expect that government could do a better job of running the railroads than private industry.

4) The general taxpayer would likely end up subsidizing the train rider to an even greater extent.

As was stated before, we have not had the time to study the question of nationalization in depth. But it is an issue that will continue to overshadow any discussion of possible solutions to the morass of problems besetting intercity passenger and freight rail service in the U.S. Research must be continued on both the costs of nationalization and the costs of not going to nationalization, in terms not only of dollars, but of energy savings, environmental protection, increased safety, and greater mobility. Only then can a rational decision on nationalization be made. We encourage a full and open debate on railroad nationalization.

References

1/ Transportation Energy Conservation Data Book Edition 3, Oak Ridge National Laboratory - 5493, February 1979, p. 1-17.

2/ Ibid., p. 1-18.

3/ Alternative Fuels and Intercity Trucking prepared by Ryder Program in Transportation, U. of Miami, and Escher Technology Associates, St. John's, Michigan, for DOE, June 1978, p. 37.

4/ National Transportation Policies Through the Year 2000, National Transportation Policy Study Commission, June 1979, p. 70.

5/ The Poverty of Power, Barry Commoner, Bantam Books, 1976, p. 165.

6/ National Transportation Policies Through the Year 2000, p. 71.

7/ Ibid., p. 70.

8/ The Poverty of Power, p. 178.

9/ "Public Ownership of Rail Rights of Way, Public Financing, Private Sector Operations, and the Public Interest", J. David Stein, Transportation Research Forum, 1977, p. 352.

Additional Research Needs

Federal research and development programs to supplement private sector efforts can sometimes accelerate the development of innovative equipment processes for which there may not be a strong near-term need identified in the private sector. Federal research and development will also allow policy decision-makers to be kept better informed relative to conservation potentials, where other implementation initiatives such as economic incentives/disincentives or regulations may be necessary.

Specific Federally supported research efforts recommended are:

1. Accelerated demonstration/commercialization of the propfan technology for a Mach 0.7 application.

2. Identify and commercialize the optimum energy efficient aircraft design within the Mach 0.4- to 0.8-speed range.

3. A synthetic fuels program which places primary emphasis on the production of methanol and secondary emphasis on the production of synthetic petroleum-like fuel.

4. Develop an automotive engine which is optimized for using methanol fuel.

APPENDIX

Comments of the
Transportation Review Panel

April 10, 1980
6350 Seastone Way
Sacramento, California 95831

Mr. Charles Gray, Director
Emission Control Technology Division
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, Michigan

Dear Charles:

Enclosed with this letter is a summary of my comments on the work of the "Sawhill Project's" Transportation Task Force. Most of my comments were made orally during the meeting of the Transportation Review Panel on March 19, 1980. I hope it will be helpful to you to have them summarized in written form.

In general, I think the draft Task Force report is an excellent piece of work. It shows how the United States can accomplish more energy conservation in the transportation sector than most people have ever thought to be possible. I believe there was a consensus among the engineers and scientists who worked on the Task Force and Review Panel that the measures covered on the report are technologically feasible. However, some of the conclusions may be hard for lay people to swallow. Did you notice how the non-automobile experts on the panel choked on the concept of requiring 75 miles per gallon from passenger cars during the 1990's? The credibility of the Task Force Report was really enhanced, however, when the VW representatives agreed that this was a feasible requirement and that VW had already achieved 75 miles per gallon with a Prototype Diesel Rabbit.

One issue the Review Panel did not have the opportunity to discuss was bus transportation system improvements. I think this issue needs much more consideration by your Task Force. Major improvements in bus transportation could get more commuters out of their cars voluntarily and have a significant impact on the disturbing trend toward more travel by jet aircraft (which will still be far less efficient than buses even if we slow them down and replace fan-jets with prop-fans). In my enclosed comments, I discuss my thoughts on having high speed bus lanes in the interstate system which use more luxurious buses which offer the amenities available to airline passengers today (e.g., stewardesses "first class" seating options, long non-stop trips, in-transit movies, etc.)

Please give me as much notice as possible of any further meetings you would like to have of the Review Panel or subgroups. Good luck on the final report.

Thomas Austin

App-2

COMMENTS ON POLICY INITIATIVES PROPOSED BY TRANSPORTATION TASK FORCE

April 10, 1980

Aircraft Efficiency Improvements - Task Force Recommendation: Restrict short-haul (1000 miles) cruise speeds to Mach 0.7 and replace fan jets used by aircraft in short-haul service with advanced turbo props ("prop-fans"). Potential savings: 130,000 bbls/day now, 380,000 bbls/day by 2000.

Comments: Notwithstanding the comments received from the ATA representative, this initiative appears entirely feasible. However, I think it is much too close to a business as usual approach. Serious consideration should be given to significantly lower speed limits for short-haul aircraft. Mach 0.4 may be acceptable for most short trips where a 50% drop in cruise speed would not increase total trip time (including on-road transportation at both ends) by more than 20%. Many states have done a good job adjusting to the 20%+ increase in automobile travel time on interstates that results from lowering speed limits from 70 mph to 55 mph. Perhaps the nation would adjust to slower speeds for all commercial aircraft, including those used for greater than 1000-mile long flights. The panelists who suggested slowing down jets would reduce the nation's productivity offered no data to support their views. Perhaps we could become more productive by investing some of the capital we now waste on jet fuel in more efficient industrial equipment.

Fuel Efficient Engine Oils - Task Force Recommendation: Public Information Campaign and Voluntary Labeling Program.

Comments: Proceed with a public information campaign now, but focus on how inefficient straight weight oils are. Immediately require the manufacturers to use the new "slippery" oils in all new cars (don't give them credit on the CAFE standards). Establish a standard test procedure then go with a "phase 2" public information campaign that includes efficiency ratings for all brands contained in a "buyers guide".

App. 3

April 10, 1980

Low-Energy Dissipation Tires - Task Force Recommendation: Public Information Campaign, Voluntary Tire Labeling Program. Potential savings: 400,000 bbls/day by 1984, 700,000 bbls/day by 1990.

Comments: Proceed with a public information campaign which encourages motorists to keep their tire pressures at the maximum sidewall ratings (not the manufacturers recommended level) except for a few special vehicle types such as rear engine cars. Provide incentives for states to include tire pressure checks and adjustments (to maximum sidewall rating) as part of vehicle inspection programs. Pursue legislation to protect states and state agents from lawsuits that may result from claims that accidents occurring subsequent to tire pressure increases were due to modified handling characteristics. (There seemed to be a consensus that the effects on vehicle handling would be insignificant for almost all vehicles.) Proceed with voluntary labeling.

Speed Limits - Task Force Recommendation: 1. Increase enforcement of 55 mph; 2. Reduce truck speed limit to 45 mph on multi-lane highways. Potential improvements: 1. 100,000 bbls/day; 2. 185,000 bbls/day.

Comments: Proceed with recommendation No.1. Drop recommendation No. 2. (Too much political heat for the potential savings -- may adversely affect congressional support for other measures.)

More Stringent Enforcement of Corporate Average Fuel Economy Standards. Potential savings: 91,000 bbls/day by 1985, 202,000 bbls/day by 1995.

Comments: Do not pursue this. I consider this "nibbling" at the auto makers to get more from the "contract" the government has already entered into with them for the CAFE standards through 1985. While the improvements are technologically feasible, they will require last minute changes in production plans already made. I believe pursuit of this measure will further sour the relationship between the federal government and the auto industry and prove not to be in the long term interest of the government's efforts to increase energy efficiency in the transportation sector. A good government/industry relationship is critical to the success of future CAFE standards advocated by the Task Force.

April 10, 1980

More Stringent CAFE Standards - Task Force Recommendation:

50 mpg for 1990, 80 mpg for 1995. Potential savings: 5,000,000 bbls/day by 2000.

Comments: Pursue a modified program with standards that are a function of vehicle size or utility rather than a simple CAFE standard. This will eliminate arguments against the model mix changes needed to achieve the recommended mpg levels. Elimination of the model mix change argument will, in my opinion, substantially improve the chances of congressional approval. If fuel price trends continue, the market place may result in the fleet mix needed to achieve the CAFE levels recommended by the Task Force. If the model mix does not change due to market forces, then size or utility based standards (requiring 75 mpg from 4-passenger cars) are still going to achieve the bulk of the potential savings for this measure. Federal loan guarantees probably should be a part of this program as the capital investments required to achieve the necessary technology changes may be beyond the capability of the industry.

Cylinder Deactivation (retrofit program).

Potential Savings: 160,000 bbls/day.

Comments: Do not pursue this. The adverse air quality impact could be substantial. Most in-use vehicles have very little emission control as maximum b.m.e.p. is approached. The state of California's experience with retrofit programs (for emission control systems) indicates the potential benefits are not achieved and substantial adverse public reaction occurs when people find out they don't like changes in their vehicles performance.

EXXON COMPANY, U.S.A.
POST OFFICE BOX 2180 · HOUSTON, TEXAS 77001

CORPORATE PLANNING DEPARTMENT

S.R. DODSON
COORDINATOR OF STRATEGIC PLANNING

April 11, 1980

Mr. Charles L. Gray, Division Director
Emission Control Technology Division
United States Environmental Protection Agency
Ann Arbor, Michigan 48105

Dear Charles:

As I mentioned to you on the phone earlier this week, I made most of the general points which I wish to have included in the next revision of the report on "Conservation and Alternate Fuels in the Transportation Sector" at our meeting in Washington on March 19. To recap, the primary thoughts particularly are as follows.

First, explicit costs and savings were treated in most papers, but capital costs and human capital costs were generally ignored or greatly understated. As we discussed, valuing individuals' time and value of the capital being used can shift the cost benefit analysis significantly in many of these initiatives.

Second, initiatives should not be undertaken which cost more than the likely cost of domestically produced alternate fuels. I believe that the right mix of conservation and alternate fuel production will occur to the extent the consumer sees the market price of energy. Hence, in many areas specific initiatives will not be needed. In certain regulated areas the analysis is not as clear cut, but there do appear to be many instances of this in the transportation sector.

Third, most of the papers do not take into account the impacts of accelerated capital obsolescence and the concomitant effect on productivity. One of the serious ramifications of rapid, major changes, whether induced by changes in relative prices or by regulation, is the reduction in the aggregate, usable capital stock.

Fourth, most of the economics in the initiatives are single-point estimates and no analysis has been undertaken to estimate the debits associated with any reduction in flexibility. The simplest example of this may be in the reduced flexibility associated with a two-person automobile. Such an automobile is completely satisfactory for perhaps 70 percent of the useage for a family car. However, in order to have the equivalent of a four- or six-passenger automobile, you should assume that if a two-passenger automobile is bought, a larger automobile would have to be rented when use demands more capacity.

App-6

Fifth, most of the inititives and a larger portion of the discussion in the Task Force meeting appear to be biased against the effectiveness of the marketplace. I believe that this is contrary to most emperical evidence, as well as the experience in most of the regulatory initiatives that have been taken in the energy field to date.

I hope that you will find these comments constructive. Overall, I thought that the initiatives showed a great deal of thought and imagination and, in many cases, were quite useful in causing us to take a look at something beyond the ordinary and usual as a way of dealing with the energy situation. As I mentioned to you, we will be forwarding our specific comments on the motor oil labeling initiative on April 15. I am looking forward to receiving the next version of these papers and continuing to work with you in this area.

Sincerely,

Sam

SRD/vpd

P.S. I have attached a copy of the Executive Summary of the report done by Exxon Research and Engineering for the DOE on "Alternative Energy Sources for Non-highway Transportation."

SRD

TRT

John R. Sears, Jr
Chairman
Robert R. Carter
Vice Chairman
James C. Echols
Executive Director
CHESAPEAKE
Robert R. Carter
Marian P. Whitehurst
NORFOLK
Joseph N. Green, Jr.
John R. Sears, Jr.
PORTSMOUTH
Dr. James W. Holley, III
Admiral James A. Brown
SUFFOLK
Ronald O. Hart
Andrew B. Damiani
VIRGINIA BEACH
J. Curtis Payne
Dr. J. Henry McCoy, Jr.
DEPARTMENT OF HIGHWAYS
AND TRANSPORTATION
T. Ray Hassell, III

May 15, 1980

Mr. Charles L. Gray
Division Director
Emission Control Division
United States Environmental
Protection Agency
Ann Arbor, Michigan 48105

RE: Sawhill Project

Dear Mr. Gray:

I have reviewed the second draft report on "Conservation and Alternative Fuels in the Transportation Sector" transmitted with your memorandum of May 5, 1980. I think the report in general presents the current state of the art in ridesharing, mode shifting and decreased fuel consumption and compliment the task force on an excellent job in getting to the heart of issues involved in public transportation and use of the automobile.

I read the responsibilities of the review panel given in the Forward and make the following comments concerning the implementability of several of the proposals. I believe that calling for increased speed limits for fuel efficient cars and increased speed limits for intercity buses present enforcement and general acceptance problems that negate their potential benefit and do not believe that the facts presented warrant these conclusions. I thought the section on vanpooling was outstanding but question an expanded Federal involvement in this area.

I hope these comments are helpful and compliment you again on the understanding of transportation issues expressed in the report.

Sincerely,

James C. Echols

James C. Echols
Executive Director

App- 8

Tidewater Transportation District Commission, P.O. Box [illegible], Norfolk, [illegible] 23501 Telephone (804) 627-92[illegible]

Environmental and Safety
Engineering Staff
Ford Motor Company

The American Road
Dearborn, Michigan 48121

April 1, 1980

Mr. Charles L. Gray, Director
Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, Michigan 48105

Dear Mr. Gray:

I am sending the attached as my comments on the Transportation Sector report which was the subject of your panel review on March 19, 1980.

Sincerely,

Galbreath

T. J. Galbreath

Attachment
kag

REVIEW OF THE TRANSPORTATION SECTOR REPORT
OF THE SOLAR ENERGY RESEARCH INSTITUTE
(SERI) PROGRAM

The following are my comments on the subject report.

The overall report properly addresses the various segments of the transportation industry and derives a transportation energy efficiency factor for each mode of transportation. Since rail and bus transportation indicate such high efficiency, it would seem appropriate for the report to address the possibility of proposals to generate more interest in changes of modes of transportation and what fraction of the nation's transportation needs could be coverable by improved rail and bus transportation. Ideas that transport both passengers and the passengers subsequent mode of transportation could possibly be developed into energy savings. E.G., trains that carry passengers and their automobiles; buses that also transport bicycles, motorcycles or automobiles could generate more efficient energy usage.

Aircraft

The concept of having somewhat slower but more efficient aircraft available for shorter trips is appealing. I am a little concerned about the methodology of implementation, however, more efficient transportation should result in more economical transportation and therefore a cost saving to the consumer. I am fearful, however, that legislating a short trip fuel economy standard would impose testing expenses, combined with a continual tightening of the regulations, that would eliminate the customer benefit. I would like to see the aircraft industry and airline industry positions on implementation options. Since they would be directly affected, their views should carry considerable weight.

Highway Vehicles

Fuel Efficient Oils - Ford Motor Company supports the concept of utilizing fuel efficient oils as a means of contributing to energy conservation. It is our belief, however, that a 3.5 percent improvement represents a larger gain than can be expected through the use of such oils. Ford testing has indicated a gain of 0.8 to 1.4 percent in metro/highway fuel economy as shown in the attached report.1/

Implementation through a voluntary program, with improved labeling and greater distribution of informative data is supported by Ford.

Low Energy Tires - Ford has supported the use of low energy

1/ SAE Paper #780962.

tires with its production implementation programs of the past 2 years with TRX tires and longer with radial tires. The fuel economy improvement related to usage of these tires has been factored into our production vehicles.2/ Ford supports improved identification and distribution of tire information as a means of increasing the aftermarket usage.

More Stringent Enforcement of CAFE Standards - The identification of the CAFE test procedure began with the decision that the LA-4 driving cycle represented average customer vehicle usage and as such should be the basis for determining average passenger car emission levels. It is still accepted as the basis for the CVS emission test. In the interests of minimizing test complexity, the same test cycle was accepted as representative of average passenger car usage for determination of fuel economy capability. Lack of perfect correlation between customer in-use fuel economy and CVS fuel economy now is interpreted as an indictment against the CVS procedure for fuel economy measurement. Faults are found with:

1. Cold start temperatures.
2. Driving efficiency.
3. Inertia weights vs. actual weights.
4. Road load horsepower vs. dynamometer rolls horsepower.
5. Tire pressure.
6. Aerodynamics.

As a measure of progress and comparative fuel efficiency between vehicles, if the test conditions are consistent, none of these are important. That is the purpose of the law specifying CAFE standards. Separate from that, vehicles should be labeled with some indication of what gasoline mileage the driver would expect.

A corrective action is required to get a more realistic label; but not necessarily to change the test procedure. The test procedure for CAFE must be consistent otherwise the automotive companies may have to make significant product changes to achieve the standards. Such action would certainly take more than two years to implement (Transportation paper indicates implementation in 1982). That is why Congress specified a 1975 test procedure in the EPCA.

New Products (50 mpg in 1990, 80 mpg in 1995) - This section of the paper virtually ignores the realities of designing, developing marketing (profitably) a new product in the automotive market. First, the buying trends of the customer change in an evolutionary fashion. Studebaker's and Hudson's attempts to sell

---

2/ Presentation to J. Claybrook, February 29, 1980.

innovation in the past are indicative of the problems that can arise when dramatic changes are made. The Crosley and Henry J are further examples. Although trends are changing faster today than before, the faster change relates primarily to the fuel pricing situation. As we all know, fuel prices have been prevented from following normal pricing trends that would reflect replacement costs. Assuming that fuel price controls will be eliminated as planned, pricing changes should become more gradual, and customer preferences for automobile size reductions should also become more gradual.

To assume that 78 percent of the products will be 2 passenger 1500# vehicles without waiting for the marketplace to evolve into such a product is unrealistic and irresponsible. It may be appropriate to set research goals (such as the .4 NOx research goal) of demonstrating high fuel economy with small, low powered vehicles. The research programs, and the publicity related to them, possibly including such actions as automobile show demonstrations, would make the possibilities of such products known to the buying public. If their reaction were to be favorable, the automotive companies would move toward making such products available as quickly as possible.

Relative to the technology level of the fuel efficient products, Ford will continue to work on PROCO with special emphasis now being directed toward smaller engines. Ford of Europe has begun a program to develop direct injection capability with AJ List. Results of these programs could contribute to fuel economy improvements by the 1986-90 time frame. Ford also has begun work on CVT (continuously variable transmission) with van Doorne. This program, however, is in the beginning research stages. While individual units have demonstrated functional capability, full feasibility is about 5 years. In summary, we believe that additional technological breakthrough will be required in the overall development of smaller cars, with special emphasis being placed on the CVT design.

Environmental and Safety
Engineering Staff
Ford Motor Company

The American Road
Dearborn, Michigan 48121

May 20, 1980

Mr. Charles L. Gray, Director
Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, Michigan 48105

Dear Mr. Gray:

I am writing to provide my comments relative to the Transportation Task Force Report of the SERI Solar/Conservation Study. In general the report addresses the issues that are pertinent to the subject of transportation related energy saving possibilities. For the most part, my comments are restricted to those sections of the report that pertain to highway vehicles, the fuels they use and the related economic and policy discussions.

Although the report raises the right questions in most cases it appears to summarily answer the questions based on unsupported judgments which in each instance are punitive in respect to the automobile manufacturer. For example:

- CAFE targets are recommended for cars and light duty trucks at 50 mpg 1990, at 80 mpg in 1995. The CAFE targets for 1985 @ 27½ mpg have been at least partially responsible for Chrysler's and Ford's economic problems. These would probably mark the demise of the automobile industry in the U.S. which is responsible for at least 1 in every 12 jobs. The targets should be supported with economic analyses.

  A fuel inefficiency tax of $100 (1980 dollars) per mpg per vehicle produced by a manufacturer that falls under applicable standards. After lengthy discussion of whether tax should be on manufacturer or consumer, the report recommends a manufacturer tax.

On this basis the study would have significant limitations as a policy tool. Conventional analysis gives ranges -- through optimistic and pessimistic scenarios -- the SERI study, on the other hand, describes a world and then gives the result. It is not an appropriate basis for policy decision-making.

The overall report does little to convince the reader that the many of the recommendations made are the most appropriate direction that should be taken.

In the area of increased CAFEs for instance, technical capability and feasibility is assumed on the basis of no more than 2 of one kind demonstration research vehicles (1 VW and 1 GFRP Ford) with no proven potential for mass production in either instance. Public preferences are written off with such statements as, comfort will be the "best that can be managed" under the circumstances. There should be an orderly discussion that begins with technical base for the various classes of vehicles that would form the marketplace. The projected cost of such vehicles should be developed, and the marketability of those vehicles should be supported with logical rationale. It is not enough to conclude that regulation and taxation will sell automobiles. Customers still buy vehicles.

Following are additional specific comments on the vehicle and fuels sections of the report.

Vehicles

- The report could benefit by a "roll back" analysis that includes higher operating mileage of new cars as well as light truck fuel consumption. This analysis would depict the extreme difficulty related to reducing passenger vehicle fuel consumption by factors of 2 to 3.

- The section on "More Stringent Enforcement of the CAFE Standards" (p. II-150) doesn't make any sense. Revised test procedures would not make higher mileage cars, just lower number window stickers. The problem is, "How do we improve the cars?", not how do we change the numbers.

- The More Stringent Test section also implies that the chassis roll doesn't represent the actual "on-the-road" power load since bias tires react differently on rolls than on road. This is old news. The current coast down procedures are intended to eliminate the power variance between road and rolls.

- On page II-154, the paper states that "Regulatory influence is the only viable strategy.." This statement is not true and isn't supported with any logic.

- The paper underplays the safety issue related to small cars by saying that designs have to improve and some day most cars will be small cars. Safety issues should be considered as part of a total "human welfare" assessment of the passenger car petroleum consumption issue. Other social problems related to unemployment should also be evaluated before national policy is established.

- The section on Peformance (p. II-161) does not cover the fundamental problems related to engine size required for emission control, need for safe performance at altitude, need for safe passing performance, power required for A/C operation, and the power reserve required to protect for high ambient temperature operation. The report ignores the fact that people live and drive in Arizona heat or in Denver.

- While not stated precisely, the report implies that an additional 40% reduction in vehicle weight from a current 2500 lb. vehicle can be accomplished with "no change in utility" using composite materials. This statement is not based on any cost-benefit, production feasibility analysis, and is a misleading extension of Ford's graphite demo car program. It is simply an inaccurate conclusion.
- With regard to discussions of air conditioning power requirements, there is no effort to assess the national fuel consumption impact of today's A/C systems and no basis to judge the impact of "alternate forms of cooling" that are suggested.
- With respect to fuel economy potential, the report accepts VW Sub Rabbit Research results as "state of the art" for 4-passenger cars. The report should recognize the historical "slip" between VW Research economy claims of 55-60 MPG for a one of a kind research turbocharged Rabbit vehicle (with "non-standard shift patterns" and other "tender loving care" features) relative to the 45 MPG results actually obtained with VW Diesel Rabbits under mass production and emission certification conditions.
- Using the VW 70 MPG base, the report states that "...any extrapolation to lower power, even lighter weight vehicles should not be technologically risky". (p. II-169) This approach to assessing fuel economy capability is ludicrous when the social impact of judgmental error is so critical.
- CVT's (p. II-170) are not expected to improve economy relative to the manual transmission vehicles that tend to form the "best ball" data base used for projections.
- Projections of 110-140 MPG 2-passenger cars, 78-83 MPG 4-passenger cars and 58 to 70 MPG 5/6-passenger cars and light trucks are unsupported projections based on the VW 70 MPG 4-passenger research car claims.

Fuels

- We agree that more emphasis should be placed on methanol as a transportation fuel, but not to the exclusion of synthetic gasoline. Methanol does not provide a useful alternative to the existing fleet.
- We question that methanol from biomass necesarily has a long term edge over methanol from coal. Biomass collection costs are very high, and freight considerations may limit biomass plant economics of scale.
- Hydrogen use in automotive transportation fuel is very iffy. The onboard storage problem offers no promise of quick or easy solution. Even the best hydride carries a severe weight penalty, which reflects in poor range or poor fuel economy. To compare hydrogen to the electric vehicle is to emphasize neither is a good solution at present, but at least the electric distribution and production system is in place.

- If the report is going to consider a gaseous fuel, it should consider methane as well as hydrogen. Methane has many of the advantages of hydrogen, doesn't have some of the disadvantages, and a distribution system is in place. It can be produced from coal or biomass with higher efficiency than either methanol or hydrogen.

- We agree ethanol has limited availability, but it can make a contribution and should not be dismissed summarily. The report, for example, ignores promising technology to make ethanol from cellulose. Ethanol has the significant advantage (as the report points out) of lower investment per unit, and can be turned on much faster, than methanol.

- Both ethanol and methanol may have far more value used as an injectant with gasoline to satisfy the octane requirement of more efficient, high compression engines, than used as a blend with gasoline. An engine efficiency improvement of 10-25% for the injectant over the blend is possible.

- No way does 10% methanol/90% gasoline blend have a 135 octane rating (pg. IV-9). The methanol may have a blending value of 135, but the blend with 87 octane gasoline would rate at about 92.

- Compression ratio increase (pg. IV-11) for 10% methanol blends is hardly realistic.

- Ethanol comments (pg. IV-11) are misleading. Phase separation is a problem (although less than with methanol), and 20% blends have noticeable driveability and cold starting drawbacks. The reference to 50% higher refers to compression ratio; it could be interpreted incorrectly as efficiency. And existing fleet vehicles in Brazil are not being converted to neat alcohol, and cannot be converted economically for efficient operation.

- Alcohol has too low a cetane number to be used in diesels (pgs. IV-11, IV-12) without significant engine modification -- use of glow plugs, pilot diesel fuel injection for ignition (with the alcohol carbureted), etc.

- The report glosses over the distribution system problem: who wants to invest in methanol production and distribution before vehicles to use it are available, and who's going to design and produce the vehicles before the fuel is available and a distribution system in place.

- Discussion of VMT effect of CAFE standards and fuel price (availability requires a more detailed analysis before conclusions are drawn - pg. V-2 to V-4).

- We have opposed an abrupt increase in gasoline price through taxes, as counter-productive. The sudden change would depress car sales, and slow the improvement in fleet efficiency. We favor a phase-in of any tax (except imposition as an emergency measure in event of import supply interruption, in lieu of rationing).

- The computation of the $.12 increase (pg. V-8) is flawed. It appears to assume that domestic crude prices would not increase to the effective (tax included) price of imports. That could happen only if price controls are extended, which we wholeheartedly oppose. Further, the paper does not discuss the very involved question of how the market would allocate the tax cost to products. It's not at all certain the costs would flow through pro rata, as witness the current problems over the President's $4.62/bbl import fee.

Please be informed that my participation in the Transportation Task Force Review Panel Activity should not be construed as supportive of the views expressed in the Transportation Task Force Report of the SERI Solar/Conservation Study by either myself or Ford Motor Company.

T. J. Galbreath

kag

VOLKSWAGEN OF AMERICA, INC.

27621 Parkview Boulevard
Warren, Michigan 48092
Tel. 313/574-3300
Western Union Telex 230-828

7111 E. Eleven Mile Rd.
Warren, Michigan 48090
(313) 588-5779

May 1, 1980

U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, Michigan 48105
Attn.: Charles Gray, Director
Emission Control Technology Division

Subject: Comments to draft SERI Report

Dear Mr. Gray:

Volkswagen will comment only on a portion of the SERI report. This is true for a number of reasons, but the most significant are that the majority of the report is related to areas which do not directly influence our research objectives and expenditures, and the time allotted to evaluate such a report is insufficient to properly critique all the information contained therein. Therefore, we have chosen to address only the CAFE standards proposed.

Increase in CAFE stringency

We have enclosed a copy of a paper delivered at the First International Automotive Fuel Economy Conference in Washington, D.C., October 30 through November 2, 1979. This paper summarizes VW's position, however, I would point out certain conclusions which result from this analysis.

- High CAFE standards would force us to use mostly Diesel engines which have so far unresolved problems meeting the NOx and Particulate standards already proposed.
- The theoretically obtainable minimum fuel consumption according to the paper is 80 mpg for a vehicle with a test weight of 2000 lbs. and an optimized Diesel engine and transmission. This is a calculation based on assumptions which, though reasonable in a research project, cannot be extrapolated to all production vehicles.

Porsche Audi Volkswagen

- Contradictory legislation and regulation "make the fuel economy objectives discussed earlier at least doubtful."
- The ultimate objective of the VW 2000 research vehicle was only 65 mpg composite fuel economy as described in the paper so as to be a feasible objective taking all regulation and production variation into account.
- Such speculation as is illustrated in the SERI report is impossible when the consumer reaction is unknown.
- Without the use of diesel engines even much less stringent standards than those proposed are not feasible.

Finally, the application of the proposed standard according to the SERI report itself requires the implementation of a massive urban road system the planning of which probably could not be completed in 10 years much less completed in 15 years at a time when state road funds are dwindling due to already reduced fuel consumption.

We believe that the free market system allows the customer to select the most fuel efficient vehicle for his needs. Such a system forces the manufacturer to strive for higher fuel economy on ALL vehicles rather than forcing certain vehicles out of the market. We believe that to do so will further cripple the American auto industry without providing a significant reduction of fuel consumption in the U.S. fleet.

We are currently experiencing an increase in our CAFE from 1979 to 1980 projected values from 28.6 mpg to 32 mpg and expect higher values by 1985. This is an indication of the ability of the consumer to determine in the marketplace what the CAFE will be. We support not requiring fuel economy standards beyond 1985 since to do so would seem counterproductive without massive infusions of money into this industry.

Although these comments are brief, we believe they properly address the only portion of the report we have had time to analyze. Please call with any questions.

Best Regards,

W. Groth

Wolfgang Groth
Administrator

WSA/cs

Enclosure

App-20

GM

Environmental Activities Staff
General Motors Corporation
General Motors Technical Center
Warren, Michigan 48090

March 20, 1980

Mr. Charles Gray, Director
Emission Control Technology Division
Mobile Source Air Pollution Control
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105

Dear Mr. Gray:

The following lists the comments given verbally at the review meeting yesterday relative to the Transportation Section of the Solar Energy Research Institute Report on Conservation and Alternative Fuels in the Transportation Sector through the year 2000.

Comments are individually listed under the section titles described on your main viewgraph:

- New Short-Haul Aircraft - None
- Fuel Efficient Oils - This section should be rewritten based on the information you will receive on March 28, 1980 as a result of your letter to General Motors and, as I understand, to other vehicle manufacturers and oil companies on this subject. Also, you should consider GM's comments in our letters to you dated February 25, 1980 and to Michael P. Walsh dated March 11, 1980 on this subject. (Attachments I and II respectively.)
- Tires - We are concerned with the statement in this section which indicates "advance technology tires have the potential for achieving an additional 5 to 10 percent fuel economy improvement over the tires currently available." Significant tire related fuel economy improvements were available in 1978 when GM indicated that construction improvements to then current radial tires could increase fuel economy by approximately 3.5%.

  As of today (1980), this advanced technology has been introduced into 45 to 50 percent of the GM new car fleet and will be 90 to 95 percent incorporated into the new car fleet by 1982. For reference over a baseline bias tire, the rolling resistance improvements have been approximately as follows:

20% for baseline OE radials (approx. 1975)

24% for lightweight OE radials (approx. 1977)

35% for "low rolling resistance" radials (approx. 1980-82)

43% for "low rolling resistance" radials + higher pressure (approx. 1980-82) over the baseline bias tire

Another point you may want to review is the cost estimate for rolling resistance tire tests of $40/test. Our information indicated it may be more like $800/test based on a currently-available independent test facility estimate. This cost would likely be reduced in the future by using more dedicated and less complex equipment.

The question was asked during our review meeting as to any problems that may arise by pumping the tires of all cars on the road today to the maximum pressure figure shown on the tire sidewall anytime one of these vehicles undergoes a state inspection maintenance program. Our principal concern is the handling performance compromise that would result on vehicles having a recommended pressure differential. Equal maximum pressures on front and rear tires of these vehicles would likely result in higher vehicle gains and slower response times producing less desirable handling for consumers. Of course, maximum pressure would cause ride quality depreciation for most of the vehicles currently in service that were not tuned to accommodate the higher inflation pressures.

- Enforce 55 MPH - None

- 55 MPH or Lower for Trucks - Do the fuel savings indicated for the reduced speed for trucks also include the longer trip time as a result of the lower speed limit?

The report indicates "single-unit fuel consumption is reported to be all gasoline." Our information indicates that currently it is 10 percent diesel and is expected to be 50 percent by 1985.

The report hypothesizes a "5 mph drop in average speed results in a fuel savings of 10 percent for heavy-duty vehicles." This seems high and indicates that it is linear which we question. Computer simulation runs of a baseline truck versus two different GM trucks at different speeds are shown in Attachment III.

- Better Fuel Economy Compliance - We disagree with the statement that "No additional statutory authority is needed to implement this initiative," as noted in our July 1979 Petition to EPA on "Test Procedure Changes." This would be a basic change not authorized by the Energy Policy Conservation Act. Any such change must consider the increased stringency in the Corporate Average Fuel Economy (CAFE) standards and a corresponding adjustment must be made to those standards.

  The statement that the "Net cost to the automobile manufacturers is difficult to estimate at this time, but would involve balancing added real costs due specifically to the initiative against cost benefits enjoyed in past model years by the manufacturers due to the "loopholes" that will be closed by the initiative" is irresponsible and should be deleted. The same applies to the next paragraph which indicates that manufacturers can accommodate such lowered model mpg's by a modest mix shift.

- Higher MPG Standards - Under the section, "More MPG from Vehicles is Good for Automobile Industry in the Long Term," we would agree that increased fuel efficiency is good for the nation but there may be a point where it is cheaper to develop alternate type fuels rather than continually increase the vehicle efficiency.

  Recommendation Section - It is irresponsible of the task group to only show one scenario that might attain the CAFE that is recommended. This is particularly true when the scenario is compared against population data which indicate that by 1990 69 percent of all families will have two or more people and 24 percent will have four or more. We also question the assumption that light trucks by 1990-1995 can meet the same standards as passenger cars. If the task group believes the numbers are appropriate, then several other scenarios that can attain that goal and that more nearly approximate people's needs should be developed. The big question on this scenario or any other that meets the report's goals is can the consumer accept such a drastic change, i.e., over 50 percent plus two-passenger cars in 10 to 15 years, or will the consumer just maintain his less fuel efficient vehicle considerably longer.

- Higher MPG = Higher MPH - Have the savings shown in the section entitled, "Enforce 55" been double counted in this section which also shows a savings by allowing some vehicles to go faster? If there is a need to conserve, should vehicles, other than emergency types, be permitted to go faster than 55 mph since reducing any vehicle's speed from 70 mpg to 55 mpg saves fuel?

- Fuel Economy Checkups - This section contends that "many vehicles on the road today are not performing as well as they could in terms of fuel economy because they are not kept in fuel-efficient operating condition," and cites three problem areas "in which better maintenance would restore vehicles toward more fuel-efficient operation, thereby producing fuel saving": (1) poor engine tune condition, (2) sub-opimally inflated tires, and (3) misaligned front wheels. While the conclusions seem to be valid, little data are presented to support the claims for specific improvements in fuel savings, specifically for underinflated tires and misaligned front wheels.

Poor Engine Tune Condition - This section notes that fuel economy improvements could be achieved if, during Inspection/Maintenance (I/M) programs, certain key items such as spark timing could be properly adjusted. Data obtained during the 300 vehicle EPA Restorative Maintenance program (Attachment IV, Figures 1 and 2) have shown that the majority of vehicles have timing set within specifications. Additionally, only retarded timing results in fuel economy losses and resetting vehicles with advanced timing (for the benefit of emission performance) results in fuel economy penalties. Table 1 of Attachment V, showing these effects, is also from the EPA Restorative Maintenance on Exhaust Emissions of 1975-1976 Model Year In-Use Automobiles (Attachment VI, cover sheet attached). Any effects due to maladjusted timing will become a moot point because of the parameter adjustment (anti-tampering) regulation which requires the distributor to become non-adjustable for MY 1982 as does idle speed control. Also, it should be noted that this same regulation requires the choke, vacuum break and idle mixture screws to have anti-tamper designs for MY 1981.

Spark timing is only one parameter of the various settings and adjustments necessary (and developed) to obtain the optimum compromise of emissions, driveability, and fuel economy performance. Maximum gains can be achieved only by completely setting vehicles to manufacturers' recommended specifications as shown in Table 2 - Attachment VII from the R/M report. Correction of maladjustments and disablements (which includes resetting spark advance) only resulted in a 0.073 percent increase in fuel economy for the entire fleet. Component repair and tune-up which include resetting to manufacturers' specifications resulted in a fuel economy improvement of 1.53 percent. The R/M report summarizes the findings by stating "very little change occurs in fuel economy following the three types of R/M prescribed maintenance" (see Figure 3 - Attachment VIII).

Sub-Optimally Inflated Tires - A two percent improvement is indicated in fuel economy "if all tire pressures were increased to and maintained at the vehicle manufacturer's recommended pressure." While it seems logical and has been demonstrated that improved fuel economy will result from higher tire inflation pressures, no data or references were supplied to support this claim. For additional comments regarding inflation of tires to their maximum sidewall pressure, see comments under Tire section above.

Data to support the average in-use inflation pressures are available. EPA in their various in-use surveillance programs measures and records inflation pressures as vehicles are obtained from customers for testing.

Misaligned Front Wheels - This section claims that properly aligned front wheels would result in fuel economy improvements yet no data are presented and no estimated fuel savings are claimed. The contention that "wheel alignment can be checked quickly and cheaply..." is subject to question when the entire mix of vehicle in customer use in the field is considered.

Summary - It appears the claims for fuel savings of 56,000 to 320,000 barrels per day is based almost completely on estimates. Insufficient data are presented throughout this section to arrive at these figures with any degree of confidence. General Motors does agree that vehicles should be set to manufacturers' recommended specifications whether they are engine, tire or wheel alignment adjustments.

- o Cylinder Deactivation - This approach is possible on new engines being developed but it must be looked at on a case-by-case basis and must consider durability throughout the 50,000 mile certification process. Consideration should not be given to any "across the board" retrofit program since it could cause durability problems, possible safety problems and may not provide the expected fuel savings because of frictional losses.
- o Tax Imported Crude - The market should determine F.E., not stds. or taxes.
- o Videophones Replace Air Trips - Has consideration been given to the possible increase in energy to make more video-telephones or the possible need for more lines or relay stations or do sufficient quantities currently exist?
- o Van Pooling - The one question that needs to be answered is will the consumer accept the longer travel times. As I understand it, past studies covering 20 to 30 years have shown that while distances may have increased, travel time has stayed about the same, i.e., better highways, higher speeds, etc.
- o Inter-City Transit - Same comment as for Van Pooling.
- o Intra-City Transit - Not available.
- o Inter-City Freight - Not available.
- o Radials for Trucks - Not available.
- o Alternate Fuels - Not available.

This report does not acknowledge the consumption reduction already made by the transportation sector.

G. F. Stofflet

Gerald F. Stofflet, Manager
Automotive Emission Control

GFS:mz
Attachment

APP- 25

GM

Environmental Activities Staff
General Motors Corporation
General Motors Technical Center
Warren, Michigan 48090

May 13, 1980

Mr. Charles Gray, Director
Emission Control Technology Division
Mobile Source Air Pollution Control
U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105

Dear Mr. Gray:

I have reviewed the second draft of the report entitled, "Conservation and Alternative Fuels in the Transportation Sector," which was prepared by the Transportation Task Force of the Solar Energy Research Institute (SERI)/Conservation Study. Comments on the first draft were contained in my letter to you dated March 20, 1980. As a reviewer of the report, I have a number of concerns and comments which I will list under the appropriate section. While I have noted some slight modification, the second draft, in my opinion, is basically unchanged from the first draft.

I continue to be very concerned with the general philosophy which permeates this report, i.e., the only way to conserve energy is to make severe intrusions into our free society. Statements like, "We may not agree with all the political decisions, but that's beside the point," and "Establishing standards and regulations to ensure energy efficient consumer choices can reduce energy consumption more rapidly and orderly than would occur through market forces," leads one to believe that the task force believes that the proper role for government is that of a body which tells consumers what they can and cannot purchase. Our concern which we have reiterated many times is that if standards are set too stringent and we are forced to build cars to such standards and not to consumer preferences, the nation as a whole will suffer economic losses.

This report continues to look at various severe conservation measures, which in many cases will require drastic change in consumer lifestyle. It should be noted that manufacturers for several years have had to predict well into the future how car buyers might react under circumstances that do not fully reflect reality. In large measure, public policies have shielded the consumer from significant international trends with respect to higher fuel prices and reduced availability that otherwise would have exerted a more predictable influence on buyer behavior. As a result of these price control policies, well-intentioned as they may appear, consumers' purchase decisions, rather than being based on long-term reality, have been based on artifically low fuel costs and the illusion that the supply of fuel was secure and virtually unlimited.

App. 26

Under these circumstances, it is understandable that a traditional consumer preference for larger cars has prevailed in this country and that the domestic manufacturers have responded to this demand. In retrospect, it is now clear that controls on the price and allocation of fuels has left the domestic industry vulnerable to sudden market shifts such as occurred after the oil embargo of 1973 and the Iranian crisis in early 1979.

What has happended can only, and should only, point the way to policies for the future, and reaffirm the need for less government intervention in general and removal of gasoline price controls and allocation schemes in particular. There are so many external factors of unknown dimensions that could influence consumer purchase decisions that it becomes an exercise in pure speculation to determine what level of fuel economy will be closest to what consumers demand. What the free market mix of cars will be several years in the future is highly uncertain. Standards that are too stringent will result in products that will be unacceptable to a large segment of buyers. Standards that are too low are obviously unnecessary. This same reasoning, i.e., remove price controls and let the consumer make the choice, applies to all sections of the transportation system addressed in this report.

No one knows what the free market will be several years in the future let alone 10-15 years from now. Currently, the Department of Transportation (DOT) and several other groups are attempting to assess the future. We believe much useful data will be forthcoming from these studies and, therefore, it is not desirable to enact legislation mandating post-1985 fuel economy standards. We suggest policies relating to fuel economy beyond 1985 remain flexible and that we resist the urge to regulate rigid standards that may not be in keeping with the market demand 10-15 years from now. It should be noted that the current law allows for such standards to be set by DOT and further provides for Congressional review. Allowing the marketplace to operate freely is the most efficient way to meet the nation's goal to reduce fuel consumption.

Foreward - This section states the review panel has had the opportunity to review two drafts of the report and goes on to state the attached reflects the remaining technical concerns of the review panel members. For the record, I have only had the opportunity to review one complete draft, dated March 11, 1980, and the draft dated May 5, 1980 and noted as the second draft on the cover is truly the second draft I have had the opportunity to review and even that is not complete. Both Sections IV-Policy Recommendations, and VII-Recommendations for Additional Policy Analysis and Research Needs, are missing from this second draft.

New Short-Haul Commercial Aircraft - None

Enforcement of 55 mph National Speed Limit - There are a number of discussions in this report that reference "the recent EPA 404 Report dated April 1980." It should be noted this report, which EPA was required to submit to Congress by May 1979, has not been submitted as of this date and to the best of my knowledge is in draft form and is not available to us. Thus, it makes it extremely difficult to comment on any references to this report.

Pg. II-29 Fuel Savings from Better Enforcement and/or Lowering of Heavy-Duty Vehicle Speed Limit - In my opinion, recommending a 45 mph speed limit on multi-lane highways and 55 mph speed limit on two-lane highways may force trucks to the two-lane roads possibly causing safety problems. I further question if you could ever afford strict enforcement on both multi and two-lane roads.

No mention is made of the approximately 3.4 billion gallons of gasoline that DOT/NHTSA acknowledges have been saved by the Voluntary Truck and Bus fuel economy program.

This section also indicates that fuel consumption is reduced 1.3% for each mph reduction implying that the reduction is linear which we question.

This section also ignores DOT's post-1980 Goals Study which predicts longer, heavier vehicles carrying the additional ton-miles much more efficiently, assuming the DOT size, weight, and intermodel study ordered by Congress results in the requisite legislation.

Pg. II-54 Increased Speed Limits for More Fuel Efficient Cars on Interstate Highways - I still question if there is a need to conserve, how can the task group recommend vehicles, other than emergency types, be permitted to go faster than 55 mph since reducing any vehicle's speed from 70 mph to 55 mph saves fuel. Without strict enforcement, it would appear these "special cars" could conceivably encourage increased traffic speeds of all other vehicles.

Pg. II-61 Low-Energy Dissipation Tires for Automobiles and Light Trucks - We are concerned with the statement in this section which indicates "advanced-technology tires still under development may have the potential for achieving an additional 5 to 10% fuel economy improvement, over the optimum tires currently available." This is a misleading statement since additional gains of this magnitude are out of the question in the next three years and may not occur in this century. To gain 10% in fuel economy, the existing fuel efficien tires used on General Motors 1980 "X" cars would have to reduce tire losses from 7 lb./tire to 2 lb./tire, a 71% reduction. It would appear that the task force may be ignoring traction, wear and handling requirements, which are also necessary tire performance characteristics.

Significant tire related fuel economy improvements were available in 1978 when GM indicated that construction improvements to then-current radial tires could increase fuel economy by approximately 3.5%. As of today (1980), this advance technology has been introduced into 45% to 50% of the GM new car fleet and will be 90% to 95% incorporated into the new car fleet by 1982. For reference over a baseline bias tire, the rolling resistance improvements have been approximate as follows:

20% for baseline original equipment radial (approximately 1975)
24% for lightweight original equipment radial (approximately 1977)
35% for "low rolling resistance" radial (approximately 1980-82)
43% for "low rolling resistance" radial + higher pressure
(approximately 1980-82) over the baseline bias tire.

I still question the task force's cost estimate of $80/rolling resistance tire test. Our information indicated it may be more like $800/test based on a currently-available independent test facility estimate.

Pg. II-79 Low-Energy Dissipation Tires for Heavy-Duty Trucks - I agree with the use of radial tires where they fulfill a legitimate need; however, there are several areas of concern in this section:

- Do the costs consider that new wheels are required when switching from bias-ply to radial tires?
- Radial tires are much more vulnerable to sidewall damage and may not be appropriate for limited off-road operation or where the sidewall may be subjected to curb scuffing.
- Radials do give fuel economy improvements when the vehicle is in the loaded conditon which is approximately 50% of the time. There is virtually no difference in fuel economy when the truck is empty.
- Existing maximum vehicle width laws prevent the use of wide single tires on existing trucks. Thus, trucks would have to carry two types of spare tires.

Pg. II-106 Fuel Efficient Engine Oils - Comments on this section are appropriately addressed in General Motors March 28, 1980 comments to EPA's "Draft Recommended Practice for Evaluating, Grading, and Labeling the Fuel Efficiency of Motor Vehicle Oils," see Attachment I.

Pg. II-120 Improve Engine Efficiency Through Cylinder Deactivation - While this approach is possible on new engines being developed, it still must be looked at on a case-by-case basis and must consider durability throughout the 50,000 mile certification process. Consideration should not be given to any "across the board" retrofit program since it could cause durability problems, possible emission and safety problems and may not provide the expected fuel savings because of frictional losses.

Pg. II-131 A Fuel Economy Check-Up to Assure Proper Fuel Economy Maintenance - Comments on this section remain the same as on the first draft and are as follows:

Fuel Economy Checkups - This section contends that "many vehicles on the road today are not performing as well as they could in terms of fuel economy because they are not kept in fuel-efficient operating condition," and cites three problem areas "in which better maintenance would restore vehicles toward more fuel-efficient operation, thereby producing fuel saving": (1) poor engine tune condition, (2) sub-optimally inflated tires, and (3) misaligned front wheels. While the conclusions seem to be valid, little data are presented to support the claims for specific improvements in fuel savings, specfically for under-inflated tires and misaligned front wheels.

Poor Engine Tune Condition - This section notes that fuel economy improvements could be achieved if, during Inspection/Maintenance (I/M) programs, certain key items such as spark timing could be properly adjusted. Data obtained during the 300 vehicle EPA Restorative Maintenance program (Attachment II, Figures 1 and 2) have shown that the majority of vehicles have timing set within specifications. Additionally, only retarded timing results in fuel economy losses and resetting vehicles with advanced timing (for the benefit of emission performance) results in fuel economy penalties. Table I of Attachment III, showing these effects, is also from the EPA Restorative Maintenance on Exhaust Emissions of 1975-1976 Model Year In-Use Automobiles (Attachment IV, cover sheet attached). Any effects due to maladjusted timing will become a moot point because of the parameter adjustment (anti-tampering) regulation which requires the distributor to become non-adjustable for MY 1982 as does idle speed control. Also, it should be noted that this same regulation requires the choke, vacuum break and idle mixture screws to have anti-tamper designs for MY 1981.

Spark timing is only one parameter of the various settings and adjustments necessary (and developed) to obtain the optimum compromise of emissions, driveability, and fuel economy performance. Maximum gains can be achieved only by completely setting vehicles to manufacturers' recommended specifications as shown in Table 2-Attachment V from the R/M report. Correction of maladjustments and disablements (which includes resetting spark advance) only resulted in a 0.073% increase in fuel economy for the entire fleet. Component repair and tune-up which include resetting to manufacturers' specifications resulted in a fuel economy improvement of 1.53%. The R/M report summarizes the findings by stating "very little change occurs in fuel economy following the three types of R/M prescribed maintenance" (see Figure 3-Attachment VI).

Sub-Optimally Inflated Tires - A 2% improvement is indicated in fuel economy "if all tire pressures were increased to and maintained at the vehicle manufacturer's recommended pressure." While it seems logical and has been demonstrated that improved fuel economy will result from higher tire inflation pressures, no data or references were supplied to support this claim. Regardin inflating tires to their maximum sidewall pressure, our principal concern is the handling performance compromise that would result on vehicles having a recommended pressure differential. Equal maximum pressures on front and rear tires of these vehicles would likely result in higher vehicle gains and slower response times producing less desirable handling for consumers. Of course, maximum pressure would cause ride quality depreciation for most of the vehicles currently in service that were not tuned to accommodate the higher inflation pressures.

Data to support the average in-use inflation pressures are available. EPA in their various in-use surveillance programs measures and records inflation pressures as vehicles are obtained from customers for testing.

Misaligned Front Wheels - This section claims that properly aligned front wheels would result in fuel economy improvements yet no data are presented and no estimated fuel savings are claimed. The contention that "wheel alignment can be checked quickly and cheaply..." is subject to question when the entire mix of vehicles in customer use in the field is considered.

Summary - It appears the claims for fuel savings of 56,000 to 320,000 barrels per day are based almost completely on estimates. Insufficient data are presented throughout this section to arrive at these figures with any degree of confidence. General Motors does agree that vehicles should be set to manufacturers' recommended specifications whether they are engine, tire or wheel alignment adjustments.

Pg. II-141 - An Energy Conservation Example Should be Set by the Federal Fleet - None

Pg. II-150 - More Stringent Enforcement of the Corporate Average Fuel Economy Standards - We continue to disagree with the statement that "No additional statutory authority is believed needed to implement this initiative," as noted in our April 17, 1980 Petition for Reconsideration of the EPA's February 19, 1980 decision denying our earier petition on "Test Procedure Changes" and our April 18, 1980 Petition for Review of the Administrator's February 19, 1980 decision in the United States Court of Appeals for the Sixth Circuit in Cincinnati. This would be a basic change not authorized by the Energy Policy Conservation Act. Any such change must consider the increased stringency in the Corporate Average Fuel Economy (CAFE) standards and a corresponding adjustment must be made to those standards.

The statement that the "Net cost to the automobile manufacturers is difficult to estimate at this time, but would involve balancing added real costs due specifically to the initiative against cost benefits enjoyed in past model years by the manufacturers due to the regulatory flexibility which would be eliminated by the initiative" is irresponsible and should be deleted. The same applies to the next paragraph which indicates that manufacturers can accommodate such lowered model mpg's by a modest mix shift.

Pg. II-156 - More Stringent and/or Restructured Fuel Economy Levels for Automobiles and Light Trucks - While we would agree that increased fuel efficiency is good for the nation, there may be a point where it is cheaper to develop alternate type fuels rather than continually increase the vehicle efficiency.

The major problem with this whole section is does the government know the consumer's needs? Can the consumer accept such a drastic change in lifestyle over the next 10-15 years or will the consumer just maintain his less fuel efficient vehicle considerably longer?

As we stated earlier, there are so many external factors of unknown dimensions that could influence consumer purchase decisions that it becomes an exercise in pure speculation as to what level of fuel economy will be closest to what consumers demand. What the free market mix of cars will be several years in the future is highly uncertain.

Our concern, which we have reiterated many times, is that if standards are set too stringent and we are forced to build cars to such standards and not to consumer preference, the nation as a whole will suffer economic losses.

Another area of concern is the validity of a survey used to determine the average number of occupants by trips taken ten years ago (1969-1970), being used as a basis to predict vehicle fleet mix fifteen years from now.

I also question the reasonableness of proposing that all light duty trucks (up to 8500 lbs. GVWR) meet the same fuel economy proposals as future passenger cars. Such a proposal will reduce the utility and load-carrying capacity of these trucks so that the small commercial businesses could be forced to buy trucks larger than their original needs and much less fuel efficient. Thus, such a proposal could be counterproductive in terms of fuel consumption.

Pg. II-190 - The EV Option - None

Pg. II-191 - Being Ahead of, or Being Behind the Market - This sections goes into quite some detail explaining the many negative impacts associated with being behind the market citing many recent articles in the press. It then goes on to say that there are no current examples of the impacts of the U.S. industry being substantially ahead of the market. Unfortunately, General Motors has had that experience in the past few years and the details are as follows:

In early 1975, small cars were in demand and it appeared that the demand would increase. At that time, GM had one plant producing Chevettes on a two-shift basis and we made the decision to convert a second plant. All tooling and machinery were delivered to the plant for an expected start of production in early 1976. Sometime after the decision to bring on a second Chevette plant, the demand for Chevette-type cars declined and we were forced to cut our first plant back to a one-shift operation due to a downturn in Chevette sales. The second Chevette plant was not brought on-stream but converted to large cars.

In June 1977, it appeared small car sales would pick up and we were about to introduce another model of the Chevette and the second shift was reinstated in our first Chevette plant. Near this same time, the decision was made to bring on a second Chevette plant for start of production March 1979. In August 1978 (start of production 1979 model year), sales of foreign-produced automobiles like the small domestics, were slower than expected. By December 1979, just before the Iranian situation, the day's supply of these types of cars rose to 154 for imports and 99 for Chevettes (a 60-day supply is considere average).

Thus, the saml1 cars were available but the consumer was not buying, yet mid-size and large cars were in short supply. Our concern is that this could happen again only producing a much more severe condition if such drastic changes in lifestyle are regulated and the consumer refuses to change.

Pg. III-1 - Transportation Mode Shifting - Public Transit: The discussion of transfer from automobile to transit indicated the difficulties but could have more effectively defined the problems, and indicated the areas in which solutions are possible. Comment on problems: (1) The energy efficiency of public transit versus the automobile will decrease as additional trips are attracted, and there will be a peak level of ridership (approximately three times today's) above which energy consumption may actually increase; (2) That public transit will be a necessary element in a plan for a serious energy emergency; and (3) The report emphasized direct operating costs and the need for subsidy. Capital requirements also are very significant. The capital required to achieve peak energy efficiency is about 250 billion 1980 dollars. Option for the Future: Since trip time is a major factor in selecting travel mode, more express service could attract higher ridership.

Pg. III-7 - Shift of Freight from Truck to Rail - The report lists a number of government actions which could be taken to encourage shippers to select rail--

without addressing some key questions. In summary, we believe:

(1) That there will be a significant change from truck to rail as a direct result of passing through energy costs to the shipper. While the results are as yet tentative, it appears that fuel prices in the $2.00 range could lead to a shift of as much as 50% of the trips over 200 miles.

(2) The major limitations are availability of equipment and useful loading docks, It appears that the majority of the factories and warehouses in the U.S. built since 1960 do not have rail access.

(3) Piggyback (truck or flat car) will have the easiest time absorbing the growth since most of the increase will have to be trucked at one or both ends of the trip.

(4) The major needs for increased intermodal are for well-located yards with adequate capacity and rolling stock. Federal assistance in locating and acquiring yard sights could be beneficial.

(5) If market effects will divert significant tonnage to rail, the punitive policies described to inhibit truck use could be disastrous to both the long haul truck user (which could divert to rail) and the short haul which cannot.

Pg. III-30 - Initiative to Encourage Urban Transit System Mode Use and Expansion - The underlying premise of this section is valid. That is, the transit property (and its officials)should be rewarded as a function of the productivity. At present, there are no incentives for real initiative in operation or equipment. The operator who innovates faces a personal risk.

However, the discussion places primary emphasis on cost to the user, and almost ignores an equally important parameter: time. The service must be improved to attract the riders. Punitive measures, like road taxes and fare subsidies will be self-defeating unless the riders' needs are well addressed.

There is an implied assumption that transit passenger miles can be equated directly with energy savings. This does not hold in the real case. In any given city service levels which provide the maximum energy savings are well below those which attract the maximum number of passengers.

Pg. III-44 - Encouraging Van Pooling - None

Pg. III-59 - Energy Savings Through the Increased Use of Video-Telephone Conferences - None

Pg. III-67 - Intercity Services - High speed intercity trains operating at distances up to 200 miles have the potential of attracting riders from automobiles and aircraft if the elapsed time is significantly lower.

The capital cost of the new facilities has not been established with confidence but will be high. Research in improved suspension systems may lead to lower cost high speed systems, but the time period will be long.

Pg. IV-1 - Alternative Fuels - Attachment VII is a recent General Motors publication on this subject.

Pg. V-1 - Economic Disincentives - A Tax on Imported Petroleum - Our main concern is that this initiative will be very inflationary on top of what the current administration has already proposed. Further, data are lacking to support the conclusions. As we have stated earlier, we believe allowing the marketplace to operate freely is the most efficient way to meet the nation's goal to reduce fuel consumption.

Pg. VI - Policy Recommendations - Not included in the second draft dated May 5,19

Pg. VII - Recommendations for Additional Policy Analysis and Research Needs - Not included in the second draft dated May 5, 1980.

As noted in the beginning of this letter, I am very concerned with the general philosophy of this report, i.e., the only way to conserve energy is to make severe intrusions into our free society. Further, in my opinion, there has been little change between the first and second draft report.

Finally, I want to make it perfectly clear that in no way should the written comments that I submitted to you on March 20, 1980 or these comments be interpreted as endorsing or approving the material contained in the two darfts by either the undersigned or General Motors.

Very truly yours,

Gerald F. Stofflet, Manager
Automotive Emission Control

att.
mlz
cc: D. Horgan
A. Sobey

Cummins Engine Company, Inc.

Columbus, Indiana 47201 Telephone: 812 372 7211

May 17, 1980

Mr. Charles Gray, Jr.
Chairman
Transportation Task Force
SERI Solar/Conservation Study
(Sawhill Project)
Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, Michigan 48105

Dear Charles:

Mr. Stoner, who has been away from the office for the last two weeks or so, asked me to compile the comments we have received on the two drafts of the report entitled Conservation and Alternative Fuels in the Transportation Sector.

I enclose the first of two sections of comments. The second section is still being typed. I will forward it to you by Federal Express early next week.

I hope these will be of some use.

I beg your indulgence for the tardiness of our response. We are short two people in my area and, as a result, a back log of sorts has developed on several projects. I am at fault.

With best wishes,

Sincerely,

Michael F Brewer

M. F. Brewer/cs

Director - Public Policy/
Government Relations

Attachment

COMMENT ON CONSERVATION AND ALTERNATIVE FUELS IN THE TRANSPORTATION SECTOR

(Sawhill Project)

General Comments

The major line of reasoning of the Panel's Introduction is unclear. It appears to have two deficiencies.

> The facts are not presented in the most useful way, or are too general. For instance, in Table I, all trucks are lumped together into one category. Yet trucks are really of at least two very different types in terms of their uses -- light-duty vehicles are for largely personal uses or mixed personal and small scale commercial use; while heavy-duty vehicles are for large scale intra-urban, regional and cross-country commercial use. Many trucks are more like automobiles than like heavy-duty trucks. Since heavy-duty trucks consume about 5 percent of all liquid petroleum fuel, and since transportation accounts for about 52 percent of all liquid petroleum fuel use, heavy-duty trucks consume about 9 percent of all liquid petroleum fuels used for transportation. Thus, Table I ought to reflect this distinction between trucks according to their predominant use. This is important in comparing properly the physical energy efficiencies of rail versus truck. In each case, you want to compare the relative energy efficiency of alternate modes for performing the same physical commercial task.
>
> For another example, in Table 2, the use of system-wide averages in comparing physical energy efficiency per-ton-mile or per-passenger-mile (physical units of measure) is not very informative despite its apparent value. According to initial results of a recent analysis of freight vehicle fuel efficiency comparisons by Stanford Research Institute (SRI), "the system average energy consumed per unit weight of delivered freight is not a valid basis for comparing the fuel efficiencies of the available transportation modes." The better basis of comparison is between two modes within the same competitive class of service or commodity or traffic corridor. Fuel efficiency differences within many competitive classes are much smaller than system averages.
>
> Differences of opinion over the relevancy of facts in the format presented are less important than differences over fundamental assumptions. The Task Force seems to believe two

things. First, it suggests that the energy input (in the case of transportation, almost all liquid fuels) is the only input to worry about. In effect, energy is given an absolute value. Second, it suggests that the relevant variable is differences in physical units of liquid petroleum fuel for a standard physical unit of work (i.e., gallons of oil per-ton-mile). But this leaves out the importance of other inputs (non-energy) and ignores the whole concept of value, which is the basis on which people make decisions as to which mode they will employ.

The standard for comparison should be a common measure of the economic value to be derived from choosing one mode over the other. The cost of energy input in each mode for the same job is one factor, an increasingly important one, but not the sole one, in determining the net value of a modal choice.

It is interesting that the Task Force implicitly recognizes this in evaluating its policies to conserve liquid fuels in light of their relative impact on safety, environment, competition and other social goods or externalities. This is a good and correct thing to do because it recognizes there are other things of value than just reducing liquid fuels input. In fact, it is the relative values among those factors that determines the "correct" choice.

None of this is intended to minimize the difficulties of placing upon such external or social factors values which will find broad agreement. Measurement problems are very real, as is that availability of good data; but analytically and practically, it is essential to take into account these social goods such as safety and environmental quality; for too long, this country ignored these goods at great cost to public health, aesthetic satisfaction, etc. For instance, a regulatory policy that insisted that all central power systems switch to coal from sulfur-free fuel oil in order to conserve liquid fuels might well be in error. It is conceivable that in some places, the environmental cost of burning coal would substantially outweigh the value of saving some amount of liquid fuels. If so, value to society is maximized by allowing the burning of liquid fuels instead of coal in these places.

But what is true for these external or social goods is equally true for all inputs and all outputs. For any given task, the key is to get the maximum economic value (including public and private benefits) out of the minimum value of a variety of inputs (including public and private costs). The relative impact of two transportation choices on liquid energy use is a useful thing of which to be aware, but it is not the complete picture. Focussing on this outcome (minimize liquid fuel use for a given physical amount of work) will not give the socially (public plus private net benefits) correct answers in all or even many cases.

I hasten to add this is not a plea for a market solution. But every regulatory decision, whether of the market variety (which is a form of regulation) or of the central directive or command and control type, implicitly sets relative values upon all the inputs (costs) with respect to an outcome with an agreed-upon value. It is a tough problem to know what relative value to assign to each of these inputs (or for that matter to the output) -- in many cases the market does rather well, but not always, and the market does not always work well at a time of rapidly changing value or of sudden shocks or where there is a great divergence between public and private net benefits -- but the fact is that somehow the market or regulator has to assign relative values to all these inputs and outputs. And consistently "wrong" assignments will impoverish a society economically and spiritually. (There may be special cases where decisions on the basis of physical units make apparent sense; for instance, where a fixed amount of food must be divided among several people it will be critical to ensure each gets the minimum calories to sustain life; but even here it is conceivable that there are several combinations of food stuffs which will yield the same minimum calorie level, thus providing the basis for trade of certain food items for other food items (or for other non-food items) among the several people to maximize satisfaction of individual tastes).

Thus, the issue is what relative value to place upon liquid petroleum fuels use. The Task Force in its Introduction touches upon some of these -- costs of extraction; intergenerational equity; national security costs; etc. -- but still seems to rest its analysis on relative differences in fuel consumption per passenger-mile or per-ton-mile. The implicit assumption is that a ton-mile is a standard or common measure (a measure of value) by which valid comparisons can be made, but this implicit assumption is false.

Efforts to conserve liquid fuels need to look at two situations. Are there situations in which some amount of liquid fuel is being used to achieve an economic value which could be achieved with a lesser amount of such fuel, everything else being equal? This is a case of pure waste. Where such instances can be identified, and the costs of identifying and acting upon them (information, compliance, transaction costs) are not greater than the value of the liquid fuels saved, then for a society such "conservation" is a must.

The second situation is where a different mix of inputs, including capital inputs, involving a decrease in liquid petroleum fuels, can achieve a greater net value by making the change. Once again, the correct decision will turn upon the relative values to be assigned to each variable. And, as stated above, this will not be easy. The point is that every regulatory decision (market, bureaucratic, etc.) implicitly assigns these economic values.

For instance, if the proper basis for a decision to favor one mode of transportation over another were relative differences in physical units of liquid petroleum fuels used, then we could eliminate our liquid fuels problem by returning to travel on foot and shipment by ox cart. Obviously, the consequences would not be to the liking of many of us, but it would achieve the stated purpose.

Clearly, the Task Force did not intend to suggest such a remedy. Moreover, there are several places in the introduction in which the correct decisions turn upon relative valuation of several factors. The point is simply that the Introduction is unclear whether relative economic values -- no matter how much we may disagree over the best ways to determine these values -- taking into account all the variables (of all inputs and outputs, private and public), is the critical issue in selecting among policy choices.

What we want to avoid as a society is selecting policies which cost us far more in terms of the value of other resources (material and non-material) than we save in conserving on the use of a certain amount of liquid petroleum fuels. It is not a physical engineering solution we seek, although engineering analysis will be very important in shaping many possible policies, but an economic solution. What we want is to use liquid petroleum fuels in those activities where their use in conjunction with other resources will produce the greatest net value (private plus public). Where society will face the sharpest disagreement is how much value to assign to such things as reducing our economic, social and military dependency upon imported liquid petroleum crude and fuels.

The following schematic outline is offered for your consideration for the introduction:

> Our problem is dependency on liquid petroleum fuels, particularly imported liquid petroleum fuels.

Substitutes for liquid petroleum fuels not readily available.

Cannot be supplied at competitive price or in amounts needed;

Technology not yet developed;

Environmental consequences and costs of some possible substitutes very high (acid rain from switching from oil to coal in central electrical plants).

Our challenge to transform our economy from one based on relatively high cost energy.

Time for adjustment important:

Immediate term: 1 - 2 years;

Near term: 3 - 10 years;

Long term: 11 - 30 years;

In immediate and near term, conservation offers real opportunities.

Immediate problems:

Reduce dependence on imported oil, especially Mid-East;

Make sure price reflects true value (private and social) of oil;

Help those who can least afford it adjust more easily over time;

Cooperate with allies to share burdens of sudden disruption in supply to avoid panic spot-buying and every-one-for-himself behavior;

Build up strategic petroleum reserves;

By various government policies (market and non-market regulatory) encourage use of liquid petroleum fuels in those activities where in combination with other factors (now and over time) the highest net economic value (private plus public) is achievable;

By various cost effective government policies (market and non-market regulatory), eliminate pure waste of liquid petroleum fuels and encourage cost-effective substitution of other fuels and other factors of production for liquid petroleum fuels.

Avoid partial analyses -- keep eye on system-wide effects of policies.

Timetable of actions needed:

Immediate -

Conserve. More efficient use of existing supply. Eliminate waste. Substitute labor for energy. Hold level and cut back oil imports.

Near Term -

Conserve. Retrofit existing capital stock. Design new capital to use less energy. Substitute other fuels for oil. Boost production of existing energy resources. Substitute non-energy inputs for energy.

Long Term -

New energy sources. Complete phase-out of old energy intensive capital stock and replacement with new lower energy capital.

Opportunities for conservation in transportation:

Transportation uses 52 percent of liquid petroleum fuels;

Near term conservation potential high;

Encourage market to reflect true net value (private plus public) of use of liquid petroleum fuels;

Cost-effective regulation to overcome barriers (informational, scale, private transaction costs) to efficient use of liquid petroleum fuels;

No absolutes -- trade-off between competing values to achieve highest net social value -- don't overlook value of environment, safety, health, aesthetics in calculations;

Take into account total net energy costs (as well as total net other costs) in evaluating policies;

Focus is on maximizing economic value, not simply on physical quantities.

Don't overlook transactions costs in evaluating alternative policies. Free lunches are rare.

Other Comments on Introduction

Would be helpful to point out that artificially low energy prices (by government regulation) during 1970's impeded necessary adjustment to world of higher energy costs. Also, the recent large cut backs in gasoline consumption would seem to belie your doubts on page (I-7) about short-term effectiveness of rising prices in reducing demand for liquid petroleum fuels. What is not clear from data is whether this is the result of public fear about available supplies at any reasonable price versus rising price alone.

The point is that it is a mistake to have price pulling in opposite direction from other regulatory initiatives. There are tools for ensuring equity even as rising prices encourage greater efficiency. We should separate policy tools for equity and easing-burden-of-adjustment from policy tools to achieve efficiency (in total resource use, including environment, etc.).

In looking at two modes of transportation, for example, barge versus truck, the shipper is less interested in which uses less energy per-ton-mile of freight shipped than in minimizing the sum of his costs in moving the shipment of given value. At current inventory costs, an extra day or two in transit could more than offset any savings in energy costs (even if priced to reflect true total value (social plus private)).

The importance of looking at all factors of production, not energy alone, may be illustrated by pointing out that some students of the Japanese economy suggest their skill at conserving working capital (such as, minimizing time of materials, intermediate goods, final goods in transit) accounts for much of their success.

Highway Vehicles

Standard Fuel Efficiency Data - On page II-21, the Task Force states: "The Federal emission certification tests provide a ready source of such engine fuel efficiency data."

A comment from Caterpillar Tractor Company agrees that "properly derived fuel maps for engines" would be a "good tool." They stated:

> "There are a great many factors to be considered in making up truck fuel consumption results and we believe care should be exercised in using engine fuel efficiencies measured by a "standardized" procedure. We're not at all sure about using Federal emission certification tests as a source of engine fuel efficiency data. We do believe that properly derived fuel maps for engines is a good tool."

ICC Regulations Re: Empty Backhauls - On page II-21, the Task Force referred to ICC rules "which require trucks to return from delivery trips empty. . . ."

This statement confuses matters on two accounts. One, technically there is no such ICC regulation. At the margin, the effect of several taken together may contribute to that result. Two, maximizing total net value may have the result of encouraging empty backhauls at times. Obviously, in such a case, the cost to the trucker of arranging a backhaul is more than the costs, including fuel consumed, of an empty backhaul. Whether there is a divergence between private and public costs here cannot be answered in the abstract, but full value pricing of oil will help limit empty backhauls to those cases where total net value (private and public) is maximized.

On this issue, the American Trucking Associations, Inc. (ATA) stated as follows:

> "It should be pointed out that the ICC has never established any regulations which require trucks to return empty. There are rules and regulations of the ICC which relate to the kinds of commodities which can be carried and in some instances to routes but the ICC has relaxed or eliminated many of these requirements. Those which remain are clearly designed to protect shippers and the public. None of these rules and regulations ever require trucks to return empty, since all carriers have always had the opportunity to haul exempt

commodities at any time under any conditions. The statement is overly simplistic in concept and inaccurate in fact.

Enforcement of 55 mph Speed Limit - The trucking industry's responses to this initiative were that they fully support the 55 mph speed limit. Another set of comments from a Cummins engineer who looked at this initiative follows:

> Inherent inaccuracies in speed measurement makes practical enforcement of a 55 mph limit impossible.
>
> If the objective is to slow traffic down from its current approximately 60 mph average to 55 mph average to save fuel, reduce the speed limit to 50 mph and cite for speeds in excess of 55 mph.
>
> Enforcement will never be really effective as the job is too large for any practical system or method to successfully cope with. The only effective way is to allow the price of fuel, either thru market activities or taxes, to be the deterrant to wasteful use. This latter method seems to work in Japan, Germany, and other countries which import a far greater percentage of oil than we do.

Enforcement of 55 mph for Heavy-Duty Trucks - The industry is on record in support of enforcement of the 55 mph limit. How best to achieve this goal is the subject of some disagreement.

Lowering of Heavy-Duty Truck Speed Limit to 45 mph on Multi-Lane Highways - Caterpillar Tractor Company stated in response to this initiative:

> "In considering 55 mph vs. 45 mph speed limits, the productivity loss at 45 mph far outweighs the gain in mpg. The claim of 27 percent gain has real problems, particularly if rear end ratios are changed to hold nearly the same average engine RPM. We believe strict enforcement of the 55 mph-limit is far more practical and certainly far better than mandatory road speed governors. One other point: The Federal government has never undertaken the question of truck speed vs. productivity vs. number of trucks to do the job. This should be done before considering things like 45 mph."

American Trucking Associations (ATA) stated: "In regard to lowering heavy-duty truck speeds, we have attached a page from House Document No. 354, some material from "Accidents on Main Rural Highways" by David Solomon, both of which relate to the safety problems resulting from differences in speed limits and the copy of a letter which we sent to Chairman Staggers in 1973 concerning the disruption of motor carrier operations which would result from a major change in speed limits. The trucking industry has now made the necessary adjustments to conform to 55 mph speed limit operation and over-the-road driver runs have been set to be achieved in the ten hour driving limit at this speed. A further decrease to 45 mph would disrupt thousands of over-the-road runs, force terminal shifts, driver locations and undoubtedly increase by substantial numbers of the trucks required to perform the same transportation service as is being performed today. The final results will almost certainly be an increase in energy consumption to fuel the additional vehicles rather than a decrease."

The response of a Cummins engineer to this initiative is set out below:

> To reduce productivity of both drivers and equipment by reducing speeds of heavy trucks below 55 mph is inflationary.
>
> If trucks are slowed to 45 mph on dual lane roads while passenger cars remain at 55 mph, why not reduce speeds of all vehicles to 45 mph on two lane roads? This will save more fuel. It will eliminate the truck option of using secondary roads to circumvent the lowered speed on dual lane roads. It will probably not divert much passenger car travel to air since little intercity travel on two lane roads has an air travel option.
>
> In some areas adherence to a 45 mph limit will require use of brakes on downgrades. This will waste fuel.
>
> With an enforced 45 mph (trucks) and 55 mph (automobiles) arrangement, heavily loaded urban freeways would have their saturation points lowered. This will result in more and longer stagnation with more and longer idling periods for both passenger cars and trucks. This will waste more fuel.
>
> Shifting some of the cargo now hauled by trucks to rail or water will require rebuilding of rights of ways and construction of locks and dams. This will consume both energy and time. How this is to be accomplished is not addressed. A well planned and coordinated transfer would be needed to avoid serious disruptions in vital transportation areas.
>
> Because of the way some of the trucks were built, slowing

** them from 55 (or higher) to 45 may result in loss of efficiency with lowered ton-mile per gallon productivity.

Other Cummins Comments: We were persuaded by the comments offered orally by Mr. Austin of CARB at the March meeting of the Review Panel that the negative safety consequences of this initiative might well outweigh any liquid fuel savings (if any) benefits. We believe there to be many situations in the U.S. where a two lane highway parallels multi-lane. One effect of this initiative would be to encourage at the margin some (how many it is hard to say without more detailed analysis than we can do in the limited time available) shifting of heavy truck traffic to two lane highways, especially in off-peak or night-time hours. Also, according to the American Trucking Associations, 1965 FHWA Studies showed a ten mile speed differential to be very important in terms of safety. According to ATA, this result has been confirmed in subsequent studies and no contrary evidence has been presented. We do not believe the safety or environmental consequences have been fully evaluated relative to hypothesized fuel saving evaluation.

We would also raise for your analysis, the possible effect of driver behavior on the 45 mph multi-lane initiative. In order to maintain a nearly 45 mph average, the driver may be tempted to maintain his speed until the last possible moment, then brake sharply, then accelerate rapidly to achieve 45 mph as fast as possible. This non-smooth driving style might result from this initiative. If so, the use of fuel would be greater than were the style smooth gradual and even. There would also be the need to brake more going downhill than at present, another source of increased fuel use relative to the current speed limits.

On page II-29, the statistics offered in the last paragraph are interesting, but not of much use. They deal only with physical measures of energy (liquid fuel) use for total ton-miles traveled by each mode. The important data are ones expressing net economic value, however, and ones disaggregating the averages or totals for each mode into comparative (intermodel) data along specific competitive routes or for carrying the same commodities between two or more points.

On page II-31, top of the page, the projections of ton-miles traveled and fuel used from 1975 to 2000 assume no conservation. This is an unwise assumption in light of the already successful efforts to achieve greater energy efficiency by the industry (Voluntary Truck and Bus Fuel Economy Program*) and by the individ-

---

* See attachments summarizing fuel savings achieved in six years of program's existence.

Attachment 11-A

GOVERNMENT/INDUSTRY VOLUNTARY FUEL CONSERVATION PROGRAM

GUIDELINES AND POINTS

The Government/Industry Voluntary Fuel Conservation Program was initiated in July, 1975 under the leadership of the Department of Transporation in conjunction with the Department of Energy and the Environmental Protection Agency.

The program is a cooperative, government/industry effort involving government agencies, manufacturers, component suppliers, users and labor with the purpose of conserving fuel through the voluntary application of fuel conservation measures to commercial vehicles; the adoption of fuel-efficient operating and maintenance procedures by operators; and the review of economic, safety and environmental regulations to ensure compatibility with fuel conservation objectives.

The program saves fuel. For the first nine months of 1979, savings exceed a rate of 100,000 barrels a day. Over 3.9 billion gallons -- more than 93 million barrels -- have been saved in the past six years, with 32 percent of the savings attained in the first nine months of 1979 alone. This has been done without government mandates or regulations.

These savings have been achieved solely by equipping new trucks with fuel-efficient devices: diesel engines in lieu of gasoline engines, fuel-efficient, low-speed, turbo-charged diesel engines, radial tires, aerodynamic devices, demand-actuated fans, and altered drive train components.

The amount of fuel conserved is actually greater than 3.9 billion gallons, because savings achieved by the use of similar equipment installed by dealers and owners are not included in the figure.

Voluntary measures work. The program capitalizes on market forces: profit motivates the manufacturer to offer energy-saving equipment and induces the user to purchase and employ the equipment. Business sense underlies the fuel conservation effort.

The voluntary nature of the program allows the user to select the device or devices best suited to the requirements of the job

the vehicle is intended to accomplish. In fact, some manufacturers offer computerized decision-making services that are designed to help truck purchasers determine the optimal balance between economy and job requirements. Thus users can have fuel-efficient vehicles tailored to their specific needs without unwanted and costly mandated equipment or procedures. At the same time, the program saves the country millions of barrels of crude oil imports each year.

Fuel-efficient options pay for themselves. With the increased costs of diesel fuel, the dollar savings that can be realized through using fuel-efficient equipment will offset increased capital outlays. For example, a 25 percent fuel savings on a truck that travels 100,000 miles annually can mean a savings of $5,000 or more at 1979 fuel prices.

As impressive as current accomplishments are, manufacturers are not resting on any laurels. Lighter heavy-duty trucks are already on the road, hauling more cargo for the same amount of fuel used. Using space-age technology and materials, manufacturers are developing more light weight components and designs; improved aerodynamic designs for cabs; new, more efficient turbo-charged diesel engines; improved drivetrain gearing; and, in conjunction with petroleum companies, new "slippery" lubricants.

3/27/80

Attachment 11-C

U.S. Department of Transportation

news:

Office of Public Affairs
Washington, D.C. 20590

FOR RELEASE MONDAY
February 11, 1980

NHTSA --3-80 (BOAZ)
Tel. 202-426-9550

VOLUNTARY TRUCK GROUP SAVES 82.4 MILLION BARRELS OF FUEL

A joint industry-government voluntary conservation effort saved over 18.8 million barrels of truck fuel in the first six months of 1979, the U.S. Department of Transportation reported today.

In addition, independent tests conducted by 15 truck owner-operators have confirmed the fuel saving benefits of observing the 55 mph speed limit first demonstrated by the DOT-sponsored Double Nickel Challenge demonstration held in Ohio in 1978.

Joan Claybrook, head of the department's National Highway Traffic Safety Administration, said, "The conservation effort is especially noteworthy because the fuel savings are more than half the 28.8 million barrels saved by the program in 1978. Overall, this outstanding effort has saved 82.4 million barrels since it began in 1973."

NHTSA also announced the free availability of a detailed technical report for truck owner-operators entitled "Double Nickel Challenge--The Race to The Fuel Pump," documenting the economies of driving at the 55 mph speed limit.

The Joint Government-Industry Voluntary Truck and Bus Fuel Economy Improvement Program was established following the oil embargo in 1973 to encourage voluntary conservation among the nation's truck and bus operators. Today, the program includes among its members more than 250 of the nation's largest motor carriers, vehicle and engine manufacturers, industry suppliers, members of the trade press, labor groups and federal agencies.

The fuel savings are described in a new booklet "New Trucks Save Fuel--1978." They are attributed to the purchase and use of new trucks with fuel-efficient diesel engines, variable drives for cooling fans, radial tires and aerodynamic drag devices. Other substantial savings, not specifically included in this accounting, are achieved through retrofitting older trucks with fuel saving devices, improved dispatching and routing and instruction of drivers in improved driving techniques.

-more-

"A gratifying aspect of this program is that it is entirely voluntary," Claybrook said, "But it works because of the big economic stake the users of large trucks and buses have in reducing the amount of fuel they use, especially as the price continues to rise and recent shortages of supply make continued service a difficult management job."

NHTSA estimates that the amount of fuel saved by the program's participants was enough to heat more than 1.4 million American homes for the six and a half year period 1973 to June 1979.

The Double Nickel Challenge report details how 26 big rig drivers obtained increased fuel economy by driving the 55 mph speed limit, while only six drivers obtained apparently better results driving at speeds higher than 55. Engineering analyses detailed in the report show that all 32 of the truckers could have gotten better fuel economy at 55 mph than at any higher speed. The demonstration was held at a seven-and-a-half mile oval test track at the Transportation Research Center at East Liberty, Ohio, in early August of 1978.

The report discloses that the trackside results, which showed that the truckers improved fuel economy by 10.4 percent when they drove at 55, compared to an average speed of 62.3 mph, were in fact conservative. On the average, the savings are shown to be 2.2 percent for each mile per hour the truckers slow down toward 55 mph.

The repeatability of the test track results on the highway has been the subject of discussion among truck drivers. Some believe that the results obtained on a test track could not be achieved in highway driving. However, 15 of the owner-operators who took part in the demonstration in 1978 have been conducting over-the-road tests of their own since that time, and have advised NHTSA that their results show that driving at 55 not only saves fuel, but that the savings closely parallel those achieved on the test track. Savings in the truckers' tests ranged from 2.4 percent to 47 percent.

Information on the results of the Double Nickel Challenge are also available in a new leaflet entitled "65 vs 55", and a six-minute movie. Both the leaflet and the pamphlet on fuel savings are available in quantity at no charge. Copies of the 68-page technical report are available in single copies, and the 16mm movie is available for loan in either cassette or on reel.

The documents and film are available through the Voluntary Truck and Bus Fuel Economy Improvement Program, U.S. Department of Transportation, NRD-22, Washington, D.C. 20590.

Individuals or companies interested in the program or wishing to join the volunteer effort should address their inquiries to the same address.

- - - - - - - - - - - - - -

ual firms (manufacturers and operators). Initiatives in engine design promise fuel use savings potential of as much as 25 percent for 1982 models over 1975 models. Initiatives in truck design (smooth skin, air deflectors, etc.) are successfully in practice now, too.

Naturally, it will take several years before existing capital stock is fully turned-over before the full scope of the fuel savings potential per truck is fully realized.

On page II-42, first paragraph, the Task Force errs in its logic. If some shippers use trucks because of their faster delivery potential, then for those shippers, their net value is obviously maximized by this choice. Thus, it is logically incorrect to assert, as the Task Force does, that this choice is made "despite the fact that it is often more economical to use rail." For these shippers, it is clear that for their needs, rail is not more economical than truck. The value of their mission is clearly very time sensitive, enough so to justify the use of the higher liquid fuel input mode. Perhaps the Task Force's argument is that there is a disparity between net private benefits and net public or social benefits and public intervention is needed to internalize all costs and eliminate this disparity. If so, the Task Force should address the evidence for such a claim, and also compare this initiation with other policies able to accomplish the same goal to determine which one is lowest cost. From a social viewpoint, the lowest cost solution to achieve a given benefit is always to be preferred.

Page II-43 also presents an inconsistency. If the net economic savings to the trucker is as great as the Task Force concludes, it is in the last paragraph on page II-42, then no "violator" will be "rewarded by gaining more of the jobs because of quicker delivery." Quicker delivery is clearly, by the Task Force's own analysis, going to result in a lower net benefit to the trucker offering the speedier service, other things being equal. With respect to mode shifts that might occur, as a general rule, we would endorse the idea that the lowest net cost mode is always to be preferred. If liquid fuel price reflects its true value, and neither mode benefits from subsidies (direct or indirect) or suffers from unjustified imposed cost differentials, then the lowest net cost mode will in general be chosen. We believe this to be the appropriate outcome, whether or not it would result in a shift from truck to rail.

If any loss in productivity due to lower speed limits could be made up by larger size and weight limits (assuming trucks are bearing (or were to bear) their fair share of highway construction and maintenance costs, other possibilities for radical aerodynamical redesign of trucks to reduce drag and air resistance, and thus save fuel, would emerge. Attached is an article on air deflectors and fuel consumption from the February issue of Indiana Business and Industry. If accurate, the author's projections of savings potential from reducing drag are substantial. Increased size and weight limits, perhaps as an incentive for radical aerodynamic redesign, might have a very high payoff.

One Cummins engineer, without benefit of detailed calculation, believed the Task Force's estimates on fuel savings potential, especially for the 55 mph enforcement initiative, were reasonable ones.

Finally, recent U.S. DOT tests support the finding that there are significant fuel savings for heavy-duty trucks from observing the 55 mph speed limit.

Low Energy Dissipation Tires for Heavy Trucks - In general comments are in support of this initiative. Two Cummins engineers offered following comments:

> Rolling resistance is a major factor in fuel use. Surprised it not mentioned in introductory section.
>
> Switch over would save fuel, but all factors not positive.
>
> Generally last longer, except in use off-highway or use on rough uneven surface. Therefore, offset higher initial purchasing price to some extent.
>
> Quality control problems at moment with some U.S. manufacturers. Will improve as become more familiar with the techniques.
>
> Excise tax differential seemed to make sense to him.

Another suggested that the potential savings are not as great as the Task Force analysis suggests. The reason for this, according to him, is that many operators of heavy-duty trucks currently run with very high pressures in their bias ply tires. Therefore, the savings in fuel use (not necessarily in other costs, however) due to a switch to radials may be less than envisioned assuming a lower than current average inflation pressure of bias-ply tires in heavy-duty use.

Attachment 13-A

Air deflectors and fuel consumption

by Roger J. Hawks, Ph. D.

If you have traveled on the highways recently, you may have noticed that many trucks now sport large air deflectors on the cab. The purpose of these deflectors is to reduce the air drag and thus save fuel. Many people, however, wonder if air deflectors really save fuel.

To answer this, we need to look a little more closely at air drag. Everybody has felt the force that air can exert. All you have to do is stick your hand out the window of the car when you're going about 55 miles per hour. If you have the flat of your hand forward you will feel a force of three or four pounds being exerted on it by the air drag. This force is required just to push the air out of the way. If it requires this much force to move your hand, which is only a few square inches, think of how much more force it will take to move a truck with an area of nearly 100 square feet.

At 55 miles per hour it takes over 100 horsepower just to move the air around a semitrailer truck. In fact, a truck with a 40-foot trailer must push aside 18 tons of air in every mile it travels. This air drag alone uses up more than half the power of the engine.

What is even more important is the fact that 7 percent of *all* the energy (including coal and gas) used in this country is consumed by the air drag on highway vehicles. If we can eliminate only one-fifth of this air drag, we could save 2.5 billion gallons of fuel each year.

Clearly, reducing the air drag of trucks is necessary, but does the air deflector really do it? Doesn't the truck have to push aside just as much air with the deflector as it did without? Yes, it does, but there is a difference.

Trucks, both semis and vans, always have the cab in front of the cargo space. Thus, the first thing that hits the air is the cab. As the truck moves, the cab starts to push the air aside. Due to the way truck cabs must be shaped, most of this air goes over the top of the cab. Not only is this air going over the top, but it is also going faster than the truck since it is trying to get out of the way. Unfortunately, as soon as it gets over the cab it runs headlong into the trailer and must be pushed aside again.

One cross-country road test showed the air deflector alone could save 1,200 gallons of fuel for each 100,000 miles traveled, a 6 percent reduction in fuel.

This is where the problem occurs because, now, the trailer is pushing against air that is already moving. This makes it seem as if the trailer is moving faster than it really is. Hence, the truck must work harder to move the air aside.

But that is not all. Since the edges of the trailer are somewhat square, the air cannot just move around them. Instead it separates to form a large "bubble" around the edges of the trailer. The truck must push this bubble of air along with itself. At highway speeds the air bubble can make the trailer look as if it were three feet higher and six feet wider to the oncoming air. Thus, the trailer has to push aside much more air, and the air it is pushing against is going much faster than the truck.

The air deflector attacks this problem. By having the air deflector on the cab, the deflector gets to push slower-moving air so it will not have to work as hard as the trailer. Furthermore, if the deflector is carefully designed, the separation bubble that it forms will be exactly the same size as the front of the trailer. Since this bubble will enclose the front of the trailer to the air, it appears that the trailer is not even there. The overall result is, with the air deflector, the truck has less air to move aside and the air that is being shoved is moving more slowly so the truck does not have to work as hard. The air drag on the truck is then reduced by as much as 30 percent.

Of course, the air deflector is not perfect. When a cross wind is blowing so the air strikes the side of the truck, the wind through the gap between the cab and the trailer can blow away the separation bubble formed by the deflector. The air deflector then does not completely shield the trailer so some of the trailer must still push against the high-speed air. This reduces the drag savings only 10 to 15 percent.

Additional gains in fuel economy can be made by means other than reducing the air drag. The cooling fan for the radiator, for example, eats up 16 horsepower, but may actually be needed only 2 percent of the time. A radiator fan that runs only when needed can provide significant savings in fuel. The tires also have a big effect on fuel consumption. Changing from bias-ply to radial tires can reduce the fuel used by a truck by 10 percent. Higher torque, lower revolutions-per-minute engines are more efficient, and changing from tandem-drive axles to a single-drive axle with an undriven tag axle will also improve efficiency. Together these increases can give a 2 to 3 percent improvement in fuel economy.

Another easy way to save fuel is to increase the load carried. It takes more fuel to run a heavier truck, but a heavy truck uses less fuel in one trip than a light one does in two. Currently, the average loaded truck weighs about 55,000 pounds. If this could be increased to the maximum of 73,280 pounds set by federal law, fuel consumption nationwide would be decreased 29 percent.

Taking advantage of all these ways to reduce fuel consumption, it would be possible to increase the miles-per-gallon rating of most trucks by 30 to 40 percent. ★

One more general comment. Where no net cost savings to the trucker is projected by the Task Force, the cost to society in terms of alternate uses for the real resources used for incentives or penalties to induce a switch-over to radials anyway to save fuel should be weighed against resource costs of other alternatives. Two criteria would seem to be useful:

> Where real resources so used would exceed in value the real resources needed to "buy" the liquid fuels being saved, their social welfare is optimized by "buying" the liquid fuels rather than conserving them (this assumes "price" of liquid fuels is the full cost "price")(private plus social costs such as national security risk, etc.).
>
> Where fewer real resources can be used to achieve the same fuel savings with one alternative compared to another, the lower cost alternative is to be preferred. For instance, here one might compare the real resource costs of an effective strategic stockpile versus inducing certain truck users to shift to radials in the absence of any cost-savings to the trucker.

Finally, in doing its calculations, the Task Force should try to express its fuel use savings in terms of fewer barrels of imported oil, and should beware of understating the true economic benefits of liquid-fuel use conservation measures that can result in reducing at the margin oil imports. The economic cost saved (economic benefits) from importing fewer barrels of oil is not accurately measured by the price per barrel at which the oil is imported (in fact it would understate the economic cost savings or the economic benefits). This is best illustrated by the following analysis from the book entitled Thinking Through The Energy Problem by Thomas C. Schelling, published by the Committee for Economic Development in 1979.

Following excerpt from "Thinking Through The Energy Problem" by Thomas C. Schelling, pages 29 and 30.

> has agreed to share available oil resources with the other IEA governments and to draw down emergency stocks in the event another OPEC embargo causes shortfalls that exceed specified percentages of normal supply. Performance in such an emergency is not guaranteed, but the leadership and leverage that the United States could exercise would depend not only on the willingness but on the ability of the United States to limit imports in accordance with the sharing formula in such an emergency.

Finally, the relation of oil prices to the quantities we import, or to the quantities that other countries import, can be crucial in determining the "cost" of additional imports or the "savings" due to reduced imports. There is no reliable way to calculate the effect of changes in world import demand on the prices that will be set or obtained by OPEC countries. It is almost certain, however, that reduced demand for imports will soften prices or slow their climb, while increased demand would hold prices up or accelerate their climb, especially when, as it is expected, total demand for OPEC oil approaches the projected limits on OPEC supply capabilities in another decade. A consequence of this price-quantity relation is that the true economic cost of importing more (or the costs saved by importing fewer barrels of oil) is not accurately measured by the price per barrel at which the oil is imported.

Purely as illustration, consider the difference between the estimate in the National Energy Plan that its proposed program could result in oil imports in 1985 of about seven million barrels per day compared with twelve to sixteen million in the absence of the program. Scale that import difference down to a more modest four million barrels per day, eight million vs. twelve million barrels. Assume the price corresponding to eight million barrels would be $15 per barrel, and that with the higher level of imports (perhaps with some imitation by other IEA countries that observe the U.S. not greatly conserving imports) prices in the late 1980s would be higher by 20 percent, or $18 per barrel. The "cost" to American consumers of the additional four million barrels is not just the higher price of $18. Eight million barrels at $15 would cost $120 million; twelve million at $18 would cost $216 million. The difference is $96 million, which comes to $24 per barrel for the extra four million. (The four million additional barrels cost $18 apiece and add $3 per barrel to the eight million barrels already being imported).

(Moreover, other countries also are paying an increase of $3 per barrel as a cost of *our* extra four million barrels.)

In the same way, if we hold imports to the lower level but other consuming countries let their imports increase so much that the price is $3 higher after 1985, we pay the extra $3 on our eight million barrels, or $24 million per day as *our* "cost" of *their* additional imports.

A final point needs to be made about the market for oil. We noted above that it is indeed a "world market" because of the large quantities that can shift from particular buyers to particular sellers, the ease with which oil can be redirected or resold, and the impossibility of identifying individual refineries' products and policing any program of selective denial. That is quite separate from whether competition determines the market price or prices are set arbitrarily by a cartel, or at least substantially influenced by a single large supplier or a few suppliers

> that together can manipulate the price by the quantities they are willing to sell. It has been argued that OPEC is by itself responsible for the energy crisis and that a primary policy objective should be to find a way to dissolve OPEC or to coerce it, through economic measures or otherwise, to lower its price. The price of petroleum advanced so decisively when OPEC acquired political cohesion in the aftermath of the October War of 1973, leading to the popular discovery of the "energy crisis," that there is a temptation to believe that if their political cohesion—initially an Arab-nation phenomenon arising in war—could be dissolved or moderated, petroleum prices would recede and the energy crisis would return to its benign nonexistence of a decade ago.
>
> Looking backwards five years, one may find that interpretation of the "crisis" plausible. Looking forward any distance, the coming increase in the cost of fuel appears to be much less dependent on OPEC behavior. Although the oil-production

This latter point is really a general point that applies to the cost savings analysis of all proposed initiatives.

Fuel Efficient Engine Oils - In general, comments were in support of this initiative, at least with respect to voluntary labeling and aggressive public information techniques. One Cummins engineer commented:

> It has been conclusively proven that fuel economy can be improved by use of engine lubrication oils which have a lower operating viscosity. Using SAE 10W oil vs. SAE 40W oil will result in a fuel savings; however, at high operating temperatures more engine wear or damage may occur. Multigrade oils effectively resolve these problems. A 10W-40W oil has the lower viscosity for fuel savings at lower temperatures and high viscosity for engine protection at high temperatures.
>
> The multigrade oils are used almost exclusively in automobiles in the northern half of the U.S. Low temperature starting is significantly improved in addition to improved fuel economy and in some cases lower oil consumption. Incentive programs to expand the use of multigrade oils will reduce the fuel consumed. Heavy-duty diesel engines also react favorably to multigrade oils, however, probably not to the extent gasoline engines react. We have no fleet data to support an improvement percentage, but, dynamometer data would indicate 1 to 1.5 percent could be anticipated.
>
> The effectiveness of the friction modified oil is not so

evident. In engines which operate at high speeds and high temperatures most of the time there may be a measurable improvement in fuel economy, however, engines which operate over a wide range of speeds and temperatures may have a resulting loss in fuel economy.

We have no experience with the friction modified lube oils in heavy-duty diesel engines. The actual energy used to overcome the sliding friction in a diesel engine is quite low, less than 2 percent of the total energy input to the engine. If the friction of the oil were reduced 50 percent (which is unlikely) the fuel saved would be one percent or less. This is a worthwhile reduction and the industry will evaluate such oils when they become available.

Educational programs of the potential benefits of multigrade oils and "friction modified oils" is the best proposal to have a significant impact on overall fuel usage.

Many of the improvements being made in gasoline and diesel engines to obtain better fuel economy are related to reduction of frictional losses within the engine. A smaller engine has less friction than a larger engine, therefore, the effect of lube oil improvements will be lessened.

In summary, we agree that incentives towards more "fuel efficient lube oils" will reduce the overall fuel usage, however, we think a five - six percent reduction from today's usage is unrealistic. As more smaller and more efficient engines are used, the effective reductions in fuel usage due to use of multigrade or friction modified oil will be significantly less. Therefore, we would predict that the effects of the proposed incentives to use the multigrade, and/or friction modified oils will result in a two to three percent reduction in fuel usage in the first two to five years, but as more vehicles and engines are downsized and improved these improvements will be lessened.

Another Cummins engineer commented that fuel savings from better engine oils are not as important potentially as fuel savings from better lubricants in differentials and transmissions of heavy-duty trucks. He suggested looking at these lubricants as well as engine oils.

A comment from a Caterpillar Tractor Company engineer was: "Cost effectiveness of synthetic oils may be greater in transmissions and rear ends than for engine oils."

Finally, another Cummins engineer suggested refinements in oil temperature control over the operating cycle of the engine as possible alternatives to superlubricants.

Additional Initiatives Not in Task Force Draft - One commenter noted that cost analysis sophistication does not exist evenly throughout the trucking industry. Perhaps additional efforts to make all segments of the trucking industry more aware of cost-effective fuel saving techniques would have a high social pay-off. Rapid price increases in diesel and gasoline fuels are driving more and more parts of the industry to the use of more sensitive, sophisticated cost analysis.

A Cummins engineer recommended the following initiative for analysis by the Task Force. It is in the nature of conservation by cost-effective retrofit of some of the existing stock of automobiles and light-duty vans. He calls it: Retrofit Overdrive for In-Use Cars and Light Trucks or Vans.

There are many of todays vehicles which have 300, 350, 400, and even 460 cubic inch displacement engines. Were these vehicles equipped with an aftermarket retro-fit over-drive as now used on some Ford cars, a substantial reduction in fuel usage would result.

A 1.1 over-drive at 55 mph would probably give a 3-5 percent reduction in fuel used if applied with a 300 cubic inch or larger engine. A 1.2 over-drive at 55 mph would probably give a 10 percent improvement, but may only be applicable to 350 cubic inches or larger engines. The 400 cu-in. plus engines could tolerate a 1.3 over-drive which would give a 15 percent or more improvement. Normally an over-drive is specified as:

$$\frac{1}{1.1} \text{ or } .9,\ \frac{1}{1.2} = .87, \text{ or } \frac{1}{1.3} \text{ or } .76.$$

It is estimated that such retro-fits would cost $300 to $500 to the owners; therefore, would be a most cost effective method of saving fuel - as a secondary benefit an engine tune-up at time of installation to assure best performance would produce a further gain.

The automakers probably will not support this as it would have an impact on the new car sales. However, there are many car owners who would readily spend $300-500 to up-grade their present car, but cannot afford to buy one of the new fuel efficient cars.

Comments on Initiatives Unrelated to Heavy Truck Industry

One Cummins engineer wrote up some comments upon an earlier draft of the CAFE, the electric vehicle, the cylinder deactivation, and the imported petroleum tax initiatives. Assuming they are not outdated by changes made by the Task Force in the most recent draft, we attach his comments for whatever value they may be to the Task Force.

More Stringent Enforcement of CAFE - This initiative would save fuel as stated if it is assumed the total miles driven per year remains unchanged. But this assumption (constant VMT) is not realistic.

If implementation is by buyer incentives to persuade model mix shift, there is likely to be needed an increase in price for the higher mpg models as well as an even larger increase in the price of lower mpg models, in order to provide sufficient total profitability to the manufacturers. This will financially adversely impact the buyer of high mpg models -- and basically raise the price of all cars at an accelerated pace -- feed inflation!

It is likely this initiative will virtually require the introduction/development of improved technology and/or even smaller vehicles at earlier dates than presently planned.

Initially additional advantage to imports.

Require accelerated development and capital investment by manufacturers.

More Stringent and/or Restructured Fuel Economy Standards for Automobiles and Light Trucks

Would save fuel in the proportion suggested only if the total miles driven remains unchanged.

It may be expected that the actual result of the high mpg vehicle, together with availability of fuel which remains government regulated below world oil price equivalent level, will be a significant increase in the total miles driven.

Performance -- meaning acceleration h.p. -- here fuel price is mentioned -- and correctly suggested that acceptable performance may be a function of fuel price (via mpg potential).

Size mix - as fuel cost and availability become increasingly more difficult, and emission regulations (and safety) become increasingly more costly to meet, it should be expected that the number of vehicles per family will decrease (i.e., the 2 car family go to 1 car, the 3 car family go to 2, etc.,). Thus the number of households for which it is feasible to own and operate a 2 passenger vehicle for 78 percent of trips, and also a 4 or 6 passenger vehicle for 22 percent of trips, will decline and their solution will likely have to be owning one 6 passenger (or 4 passenger) vehicle, and no 2 passenger vehicles.

Comfort and utility:

Pickup trucks and vans, need two classes based on use:

1) Commercial.

2) Personal transportation.

Classification by registration to owner (strict substantiation for "commercial"), with high fee for personal transportation, ban recreational 4 WD's.

Degree of Technological Availability

Consider that the mentioned "tendency" in the engineering community to be conservative in estimating the values of achievable future benefits may be due to an inability to ignore the very real steeply escalating cost characteristics which virtually always attend the achievement of significant (beyond mildly evolutionary performance benefit improvements.) I.e., engineers are rarely told that they may propose and develop designs/improvements which may carry significantly higher price tags than today's models.

Body structure - 40 percent net reduction by using composite materials -- but cost? Twenty five percent reasonable.

Rolling and air resistance -- reduced by factor of 2 -- only if vehicles become very small.

Powertrain

PROCO - 20 percent fuel economy improvement.

- not demonstrated @ .4 lb/cyl.

Small diesels - IDI ~ same fuel conservation as PROCO but consider DI: ~12 to 25 percent fuel economy improvement over IDI (i.e., AVL, ELKO).

Again, assumption of constant total miles driven is not valid unless great pressure is exerted via fuel price (> 3 times present price/gal.) or via government compulsion (i.e., rationing).

Again - realistic fuel prices in the recent past, at present, and in the future would have and will get the mix as well as the probable reduction in total miles driven, and thus reduction in total fuel consumed. This initiative will not get the percent reduction claimed without fuel price pressure (or rationing coercion).

Recommendation - Neither the necessity for selecting this particular solution, nor the feasibility of the initiative have been substantiated. Nor have the economic implications been considered in other than a very cursory and narrow way.

Electric Vehicles

Realistic assessment of mpg equivalent:

Thermal eff. of central power plant	~40%
Battery charge/discharge effy.	.8 x .8 ~64%
Drive motor effy.	~80%

Overall efficiency $\cong$ .4 x .64 x .8 = .2 or 20%
(Neglecting regenerated power)

In the long term, energy from oil, gas, coal, and nuclear will be costwise equivalent on a Btu content basis.

Overall efficiency of diesel car exceeds 25%

4 passenger/2000 lb.; cruise @ 55 mph ~11 h.p.

accessory $\underline{4}$ h.p.

15 h.p.

Assume BSFC ~0.5.

In one hour fuel rate = 15 h.p. hr. x .5 #/h.p.-hr. =

7.5 #/hr.

In one hour distance = 55 miles; assume fuel density ≃

6.8 lb/gal.: $\frac{7.5}{6.8} - 1.1 \frac{\text{gal.}}{\text{hr.}}$

and, 7.5 # x 18,500 Btu/# = 138,750 Btu

Btu/passenger mile = $\frac{138,750}{55}$ = 2523 same as urban bus!

Also, 15 h.p. x 2,545 Btu/h.p.-hr. = 38,175

And, finally, diesel thermal eff. = $\frac{38,175}{138,750}$ = .275

Then proposed 1995 CAFE 80 mph $\frac{20\%}{27.5\%}$ = 58 mpg for EV.

Therefore, the assigning of any value higher than about 60 mpg to EV's is purely political.

The DOE 141 and 500 mpg assumed EV levels are unreasonably and quite arbitrarily high from a technical standpoint.

However, the large-scale use of EV's greater than a token few percent of the vehicle population does have the potential to reduce consumption of petroleum fuels, if the electric power generating plants do not burn petroleum fuels.

But, Side Effects/Concerns - Many studies of EV's in the U.S. transportation system have been done in the past 10 years, first from an exhaust emissions reduction standpoint (some sponsored by EPA and DOT), and later from an energy (petroleum fuel) conservation standpoint (DOE). Without reviewing these specifically at this time, several factors/conclusions are notable here:

No "battery breakthrough" is seen on the horizon. GM, Ford, many others are proceeding on many research and advanced development projects for improved electrochemical storage devices, including lithium chlorine, sodium sulphur, zinc air, etc. However, the only commercially feasible units are still using the old stand-by lead-acid, with energy storage densities improved recently from 10 watt-hours/pound to maybe 15 watt-hours/pound. This is equivalent to increasing vehicle range from 20 miles to 30 miles per charge (or perhaps from 30 to 45 miles per charge).

Consequently the present and foreseeable future prospect for EV's still remains:

Short range (30 to 40 mi/charge, realistically).

Heavy vehicle weight for the load carrying capacity.

Significant "fuel cost", when the battery replacement cost and short battery life due to deep discharge is considered.

Very high vehicle cost for the very limited performance, and operating costs which will probably not be as low as for the 80 mpg internal combustion engine vehicle (many assumptions are implied in this statement).

It appears probable that the "optimum" combined technical and economic solution to reduced petroleum fuel consumption will not see significant use of EV's, but rather the displacement of petroleum fuel now used for space heating by primarily electrical heating.

Engine Cylinder Deactivation - The entire discussion does not substantiate the recommendations to go ahead with this initiative (except the verification procedure).

And the proposed $20 discount doesn't appear to be a significant price reduction (from $200 installed cost) to induce buying.

If fuel price goes up, market will/may move on this one if side effects are not too bad.

Petroleum Tax

The deficiencies and economic distortions are all too clear for a retail tax -- don't do the retail tax.

Tax on imported oil -- now we are getting somewhere. Recognizes the unique ability of the marketplace to make the appropriate economic adjustments to effect real fuel conservation as well as stimulation of future domestic energy production. Do this one.

App. 64

Air Transport Association **ata** OF AMERICA

1709 New York Avenue, N.W.
Washington, D. C. 20006
Phone (202) 872-4000

March 26, 1980

Mr. Charles L. Gray
Division Director
Emissions Control Technology Division
U.S. Environmental Protection Agency
Ann Arbor, Michigan 48105

Dear Mr. Gray:

This is further to my comments made at the March 19, 1980 meeting of the Review/Advisory Committee for the Transportation Task Force of the SERI Solar/Conservation Study. In view of the late arrival in incomplete form of the draft initiatives for review, and the relatively short time provided for discussion, my remarks at the meeting were necessarily brief. (I was concerned also that I turned out to be the only aviation representative and, in fact, the only public transportation mode representative at the meeting.) In agreeing to serve on this committee, I had assumed it was because of my technical knowledge of aircraft; but there now seems to be minimum interest in the technical complexities of the problem which in my view are vital. Notwithstanding these concerns, let me attempt to put matters in perspective.

From the standpoint of commercial aviation the fundamental facts are these:

1. The U.S. scheduled airlines provide about 85% of the public passenger miles between U. S. communities and about 95% of travel abroad, and provide a vital augmentation element of the Department of Defense.

2. The airlines consume less than 4% of the total petroleum used in the U.S. while carrying 300 million passengers annually and moving nine out of every ten intercity first class letter for the Post Office and moving valuable freight.

3. Unlike other transportation modes and other users of petroleum, air transportation is "locked in" to petroleum based fuels for the foreseeable future - certainly until the year 2000.

4. The airline industry is fully conscious of the need for petroleum based fuel conservation and is making every conservation effort it can. For example, although revenue passenger miles increased some 57% in the 1973 - 1979 period, fuel consumption increased only 5%. Highway fuel consumption increased by more than 27% between 1973 and 1978 (data not yet available for 1979).

5. The airlines do not need legislation, regulation or new initiatives to prod their conservation efforts. Contrary to the apparent feeling in the task force, natural marketplace forces must be allowed to act without further government assistance or interference.

6. The airlines strongly support initiatives which would:

   a. Expedite the development of synthetic crudes.

   b. Improve the nation's airport and air traffic control system; ATC delays in 1979 wasted about 784 million gallons of fuel and cost the airlines about 1 billion dollars.

   c. Expedite the use of alternative energy sources for those industries which can use these alternate sources.

   d. Increase, rather than decrease, the R&D funds for FAA and NASA to expedite their respective efforts in the fuel conservation area.

We see little or none of these initiatives in the data provided to us thus far. We are aware of one initiative, not yet received, entitled "Reduce Peak Period Congestion at Major Air Carrier Airports." This subject has been studied exhaustively in the past by, among others, the CAB and DOT, and invariably proves to be impractical. Although the airlines would like to see peak hour congestion reduced, it should be noted that public demand, not the carriers, controls the peaking of operations. However, our suggested initiative on improving the nation's airport and air traffic control system would greatly assist in this area.

We note that only one initiative directly involves aviation (although unnecessary, uninformed and even pejorative language against aviation appears in many of the other initiative discussions), namely, the propfan aircraft for short haul markets. In the short time available for review we are not prepared to provide a detailed critique of that initiative. It can be said, however, that it is clearly based on a misunderstanding of the possibilities and progress of the research on that project. For example, the proposed initiative concludes that the advanced turboprop technology would be available "to begin service by as early as 1985." Such a notion fails to recognize that the largest advanced turboprop constructed thus far is about 2 feet in diameter, and a full scale propeller will not be flight tested until late in 1988. Even if this phase is successful, and the many problems still being investigated are resolved, there remains the problem of designing a production engine/propeller/airframe combination. The lead time involved in production of a new aircraft type from the date an airline first makes a commitment is about 6 years and several years of design refinements must precede the airline commitment. It can be seen that, if everything goes well, the earliest possible date for aircraft to enter service is about 1995 or later. Finally, airline experts are skeptical of the fuel efficiency gains envisioned and feel it to be on the order of 15-25% or less. If the fuel efficiency gains are realized, and at a price the airlines can afford, no further motivation will be needed to move in this direction - and not just for airplanes which fly less than 1000 mile trips.

In summary, there is no realistic technical basis to support the short haul aircraft initiative as conceived in the proposal. We would recommend that it be dropped in favor of one or more of the initiatives we have listed herein.

As a final thought, we question the propriety of any initiative which would constrain the freedom of the public to determine which mode of public transportation best suits its needs. It is the stated policy of the Administration to minimize government interference in the market place; we support the policy.

To assist the task force in its deliberations, at the meeting I provided you with copies of the following documents:

1. ATA Turbine Fuel Forecast 1979-1983.

2. Air Transport Report - Airline Fuel Efficiency (ATA, Jan. 1980).

3. Airline Capital Requirements in the 1980's (ATA, Sept. 1979).

4. Fuel - The Most Critical Problem Facing the U. S. Airline Industry (ATA presentation to the C.A.B. Feb. 5, 1980).

5. Energy Conservation (FAA presentation to ASCE, Jan. 17, 1980).

6. ATA Testimony March 3, 1980 before the House Subcommittee on Transportation, Aviation and Communications on the Scheduled Airline Views on the FY-1981 NASA Research and Technology Program.

7. ATA Testimony February 28, 1980 before the Subcommittee on Transportation, Aviation and Communications on the Views of the Scheduled Airlines on the FAA FY-1981 Research, Engineering and Development Program.

8. Testimony of Dr. W. B. Olstad, Acting Associate Administrator for Aeronautics and Space Technology, NASA, February 6, 1980 before the House Subcommittee on Transportation, Aviation and Communications.

9. FAA Response to User Consensus Views and Recommendations: New Engineering and Development Initiatives - Policy and Technology Choices (FAA, Dec. 1979).

I would hope that these comments are accepted in the spirit given - that of an intense interest in fuel conservation.

Sincerely,

ELThomas

E. L. Thomas
Vice President - Engineering

ELT:lbh

Air Transport Association ata OF AMERICA

1709 New York Avenue, NW
Washington, DC 20006
Phone (202) 626-4000

April 23, 1980

Mr. Charles L. Gray
Chairman
Transportation Task Force
2565 Plymouth Road
Ann Arbor, Michigan 48105

Dear Mr. Gray:

Thank you for your letter of April 15, 1980 concerning my comments on the transportation task force energy conservation report. While I appreciate the offer to provide technical comments on other non-aviation initiatives, I will continue to comment only on those initiatives where I have some knowledge and expertise.

In regard to "unnecessary and uninformed language against aviation", time does not permit a detailed critique of each of the initiatives. I will offer a general comment and some specific examples.

In general we are disturbed at the evident and uninformed bias against aviation contained in the report. For example, we are referred to as "the most energy inefficient means of passenger transport" and concern is expressed that there may be a "travel mode shift, wherein long distance travelers in a hurry choose aircraft travel in lieu of driving." Concern is expressed gasoline rationing could create a mode shift "to bus, rail, and unfortunately air." A 50 cent gasoline tax is decided against because of "an even greater threat of mode shift to the inefficient air mode". We are lumped in with the automobiles when it is indicated the largest energy savings would result from the shifting of passengers from automobiles and airplanes to buses and trains not withstanding the fact that aviation consumes only about 4 percent of the total petroleum and automobiles over seven times as much according to the attached article by the Administrator of FAA.

The aviation initiative itself contains outdated and incorrect information in addition to that I pointed out previously. It does not reflect the latest and continuing efforts of the airlines in fuel conservation or the realities of airline fuel efficiency. We have, in fact, reduced cruising speeds on the 727/737/DC-9 airplanes to very close to their optimum long range cruise speeds. Our load factors in 1979 were 63.1 percent as opposed to 55.9 percent in 1977. In fact the ATA paper of

January 1980 on Airline Fuel Efficiency which I provided you shows on an overall industry basis we have increased our passenger miles per gallon from 17.5 in 1973 to 25 in 1979. This is quite comparable to the automobile and in the higher density, short haul, routes it is believed we are significantly better than automobiles. The next generation of airplanes already on order by the airlines offer fuel efficiencies about 15 percent better than current airplanes.

If the aviation initiative is to be used at all, and we still are of the firm opinion there is no realistic technical basis to support it, it should at the very least reflect the current realities.

Among the other initiatives, perhaps the most glaring "unnecessary and uninformed" example we could find is contained in the initiative on intercity mode shifting to the bus wherein it is stated: "Perhaps the most appropriate way to derive a tax credit/rebate is to eliminate the government subsidy differential between the two inter-city common carrier modes of aircraft and bus. Certainly the logic of prefential government subsidy to the most energy inefficient intercity passenger transport mode (aircraft) bears re-examination in light of this country's energy problems. A thorough study of the full governmental subsidy of the airlines is beyond the scope of this analysis, but the operational support of the Federal Aviation Administration and the research development support of the National Aeronautics and Space Administration and the Department of Defense are key components."

In regard to the operational support of the FAA we offer the following quote from DOT Secretary Goldschmidt's testimony March 27, 1980 before the House Subcommittee on Aviation regarding airport and airways legislation:

"Specifically, we have proposed increased taxes on general aviation. We have recommended these changes because we believe that system users should pay a proportionate share of the costs of the Federal airport and airway system. Currently, aviation taxes collected from system users equate to nearly 60 percent, in the aggregate, of the costs allocable to civil aviation that are incurred by the FAA in equipping, operating, and maintaining the airport and airway system.

The users of commercial air service are paying amounts equivalent to about 90 percent of the costs incurred by the FAA in their behalf, while the comparable figure for general aviation is in the range of 10 to 18 percent, depending on certain assumptions used in the allocation of costs."

As can be seen from the attached proposed NASA budget plan for FY 1981, the aeronautical research and technology part is about $290 million out of a total of about $4.5 billion, or 6 percent. If you will review Dr. Olstad's testimony I provided you I think you will find a significant part of this is for the military. The activities of NASA are extremely important "because of our national need for a healthy aviation industry, continued preeminence in the world marketplace, effective military weapons systems, greater energy efficiency, and reduced environmental impact" to quote Dr. Olstad. I fail to see any connection between DOD efforts and airline subsidy.

We continue to stand behind our comments in my letter of March 26, 1980. The aviation fallacies in the report causes me, at least, to suspect the credibility of the data concerning the other transportation modes.

Sincerely,

E L Thomas

E. L. Thomas
Vice President
- Engineering

Attachment

ELT:sle

Charles L. Gray
Chairman
Transportation Task Force
2565 Plymouth Rd.
Ann Arbor, MI 48105

April 15, 1980

E. L. Thomas
Vice President, Engineering
Air Transport Assn.
1709 New York Ave., N.W.
Washington, D. C. 20006

Dear Mr. Thomas:

Thank you for your comments during the March 19th review of the transportation task force energy conservation report, as well as the material you gave me then and the detail comments presented in your March 26 letter.

We have made certain modifications to the "Assure That New Short Haul Commercial Aircraft Have Improved Fuel Efficiency" initiative as a result of your comments. Let me assure you that your technical critique of any of the initiatives, and especially the aircraft initiatives would be considered with high interest since the technical complexities of the problem are of such significance.

Although we respect your position that the airlines do not need legislation to maximize cost effective conservation efforts, and that natural market place forces must be allowed to act without further government assistance or interference, we do believe that the issue of the need for government stimulus to assure slower cruise speed, prop-fan short-haul aircraft should be considered by national policy makers.

In accordance with your recommendations, the need to reduce air traffic delays will be an initiative recommended for additional policy analysis, and additional aircraft fuel conservation research will be recommended.

You mentioned that unnecessary and uninformed language against aviation appears in many of the initiatives. I would much appreciate you pointing out those specific instances where incorrect or inappropriate statements were being made.

Again, thank you for the input provided thus far.

Sincerely yours,

Charles L. Gray
Chairman
Transportation Task Force
SERI Solar/Conservation Study

Air Transport Association ata OF AMERICA

1709 New York Avenue, NW
Washington, DC 20006
Phone (202) 626-4000

May 12, 1980

Mr. Charles L. Gray
Chairman
Transportation Task Force
2565 Plymouth Road
Ann Arbor, Michigan 48105

Dear Mr. Gray:

The final draft Report on Conservation and Alternative Fuels in the Transportation Sector was received May 6, 1980 with a request to "quickly review" and provide any "final" comments by May 13, 1980. Due to the late receipt of the report, the press of other business and the early response date my review has been somewhat limited.

While there have been a few changes in the aircraft initiative, they are inadequate to change our views. The report continues to suffer the problems pointed out in my letters of March 26, 1980 and April 26, 1980 and we continue to stand behind those comments. I take particular note of the policy history on pages I-4 to I-6 which I had not seen previously and which reinforces my concerns.

It is also noted that the draft report received ran through Section V and did not include Sections VI and VII. On Page II-2 of the draft report, reference is made to another aircraft initiative in Section VII on reducing peak period congestion at major air carrier airports. Obviously, this would be of interest to us.

I also note a "disclaimer" of sorts in the Foreword of the Report concerning the review panel's responsibilities. I do not think this is strong enough, particularly in view of the statement, "In fact, the review panel was charged primarily with the responsibility to ensure that the facts presented in the report were realistic and that the impacts of the individual policy initiatives were adequately and objectively presented." (Underlining added.) From my comments thus far I can hardly agree that is the case. In view of that statement, if my name is to appear in the report as a member of the review panel, it is requested that a copy of my letters be appended to the report.

You may be interested in the attached excerpt from the Federal Register concerning "Energy Conservation by Recipients of Federal Financial Assistance" issued by DOT. I have included only that portion dealing with the FAA.

Sincerely,

E L Thomas

E. L. Thomas
Vice President - Engineering

Attachment

UNIROYAL

UNIROYAL TIRE COMPANY
Division of UNIROYAL, Inc.
6600 East Jefferson Ave.
Detroit, Mich. 48232

May 16, 1980

Mr. Charles L. Gray, Jr.
Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, Michigan 48105

Subject: SERI Solar/Conservation Study
(Sawhill Project)

Dear Mr. Gray:

Thank you for the opportunity to review your second draft (May 5, 1980) of the initiative "Low-Energy Dissipation Tires for Automobile and Light Trucks." With regard to the overall impact of this initiative, my comments are as follows:

At the outset, it should be made clear that the tire industry in the United States supports the objective of reducing the amount of fuel consumed by our automotive fleet. There is no question but that this is a worthwhile public goal and one, in fact, toward which the tire industry has moved steadily in recent years through technological improvements.

For several years, the reduction of tire rolling resistance (which is the critical tire performance characteristic in relation to fuel consumption) has been a major concern of tire development engineers. Significant progress has been made, and tires being furnished to automobile manufacturers today represent a substantial improvement over the previous state-of-the-art in that regard. These improvements are also being applied to tires sold in the replacement market, and we anticipate differences will diminish markedly over the next few years.

The tire industry has been and is making concerted efforts to make the American consumer aware of the fuel efficiency advantages of radial tires. That significant headway is being realized is evidenced by the fact that adoption by the motoring public of this type of tire is steadily increasing. We estimate that some 55% of all automobiles on the road today are riding on radial tires. This represents savings already realized of approximately 1.3 billion gallons of gasoline per year.

At the time of the 1973 Arab oil embargo, only 17% of new cars made in this country came equipped with the more fuel efficient radial tires, and a scant 13% of tires sold in the replacement market were radials. Today more than 95% of all new cars come equipped with radials and approximately 50% of the replacement tires sold are radials. By 1984 virtually all new cars will be on radials and this type tire will account for 75% of the tires sold in the replacement market. This means that 80% of all cars on the highway will be equipped with radials by that time. Thus forces of the marketplace will have brought total fuel savings (conservatively estimated to be approximately 1.9 billion gallons of gasoline per year) approaching the maximum potential to be realized from conversion to radials.

As desirable as it might seem initially to force these numbers to 100%, it must be recognized that the radial tire, despite its many advantages, is not an appropriate choice for all applications. Vehicle use requirements, vehicle age, initial cost, etc. will dictate the selection of non-radial tires for some drivers, and it is important that the marketplace retain this element of choice for the consumer.

The point is that tire manufacturers, through their advertising and promotional campaigns, are already informing the public concerning the effect of radial tire usage and proper tire inflation on fuel consumption. And, as has been noted earlier, conversion of our automobile fleet to radials is progressing rapidly in an orderly fashion via the marketplace. As is mentioned in the initiative, additional legislative authority would be required to implement mandatory programs embracing any of options 2, 3, or 4. We are convinced that the very real fuel economies resulting from radial tire usage can be realized without this additional legislation.

With regard to specific points raised in this initiative, my comments are as follows:

Under Fuel Conservation Potention From the Consistent Use of Average Radial tires I question the explanation of consumers switching from radial (O.E.) to non-radials when they make replacements. The reason for the present discrepancy in O.E. and replacement sales is primarily time lag. The average car in the U.S. is six years old and before 1974 not so many cars were originally equipped with radials. I don't disagree with the numbers arrived at. When we reach equilibrium in about five years, there will probably be 15% non-radial replacement sales primarily because of tire prices.

Under Fuel Conservation Potential of Advanced Technology Radial Tires are Consistently Used, the projections are totally unrealistic. As a tire's rolling resistance diminishes, its incremental effect on fuel economy also diminishes. Accordingly, if you had tires with zero rolling resistance, you would not get the 5-10% improvement in fuel economy over current technology radials. Furthermore, it's extremely difficult to envision an additional 10-20% improvement in rolling resistance over current technology radials. To accomplish this, we have advocated a cooperative research project, through the Society of Automotive Engineers. An SAE Advisory Committee (for which I am chairman) has drafted a "Research Plan for Tire Rolling Resistance." If you don't already have one, I'll be happy to send you a copy.

I hope these comments are of help. Please keep me aprised of the status of this project.

Sincerely yours,

W. J. Woehrle
Manager, Industry Standards

WJW/ps

Additional Comments by W.J. Woehrle:

A Fuel Economy Check-Up to Assure Proper Fuel Economy Maintenance

1. Misaligned front wheels are still referred to as having an effect on fuel consumption. Our experience has shown that such a relationship does not exist.

2. We're delighted that you recognize the impact of inflation pressure on fuel economy, and we welcome any positive effort to solve the problem of under-inflated tires.

3. For inflation pressure maintenance, we feel that, once again, basic research is required. Such an approval is specifically referred to in the "SAE Proposal," which I mentioned in my comments on the "initiative."

4. A mandated "low inflation warning device" would be of great benefit for fuel economy as well as safety reasons. This currently is a "back burner" item in NHTSA's 5-year plan.

5. More "innovative" incentives are required to increase or restore the availability of air at gas stations.

6. The government should assist industry in promoting proper tire inflation and proper care by the consumer.